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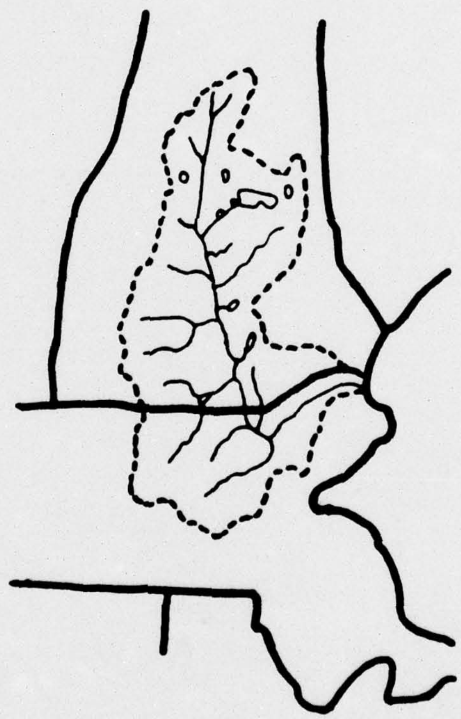

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ANNEX B,

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ANNEX B
to
THE MERRIMACK WASTEWATER FEASIBILITY STUDY

Following is a list of data prepared by private consultants for use in this feasibility study:

Annex No. B - Impact Analyses

Title of Report	Author
Ecological and Aesthetic Implications for the Merrimack Estuary of the Merrimack River Basin, Wastewater Management Alternatives	Environmental Equipment Division, EG & G
Report to the Army Corps of Engineers on the Merrimack River Wastewater Pilot Project The Social-Institutional Impacts	Dr. Hugh C. Davis
Identification and Assessment of Economic Impacts - Merrimack Impacts - Merrimack Basin Wastewater Management Study	ABT Association, Inc.
Analysis of Probable Impacts on the Aquatic Ecology of the Merrimack River Resulting from proposed Wastewater Management Alternatives	Carlozzi, Sinton, and Vilkitis, Inc.
Visual Aspects and Implications of Wastewater Management in the Merrimack River Basin (A Preliminary Assessment) (and Parts 1 and Part 2)	Prof. Walter Cudnohufsky
Institutional, Visual and Ecological Aspects of Wastewater Management in the Merrimack River Basin	Prof. Ervin H. Zube
Epidemiologic Input of Wastewater Management Program, Merrimack River Basin	Mr. G. F. Mallison U.S. Dept Public Health
The Merrimack Basin Wastewater Management Program: Terrestrial Ecological Input Considerations	N.E. Center for Continuing Education Mr. Robert H. Forste
Ocean Disposal of Sanitary Wastes	VAST, Incorporated

Title of Report	Author
Impact of Proposed Alternative Wastewater Management Systems Merrimack River Basin and Boston Massachusetts	Dr. Carl A. Carlozzi
Identification and Assessment of Social Impacts - Merrimack Basin Wastewater Management Study	ABT Associates, Inc.
Architectural Renderings and Considerations	Paul Spreiregen, AIA
Letter dated July 29, 1971 from Northeastern Water Hygiene Laboratory, Division of Water Hygiene, Environmental Protection Agency	Dr. Oscar C. Liu
Notes on Conference of Consultants Wastewater Management Program For the Merrimack River Basin	Dr. Bernard Berger

ECOLOGICAL AND AESTHETIC IMPLICATIONS FOR THE MERRIMACK ESTUARY OF THE MERRIMACK BASIN WASTEWATER MANAGEMENT ALTERNATIVES

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July 15, 1971

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ECOLOGICAL AND AESTHETIC IMPLICATIONS FOR THE MERRIMACK ESTUARY OF THE MERRIMACK BASIN WASTEWATER MANAGEMENT ALTERNATIVES

Purpose

The purpose of this report is to summarize the present physical and biological condition of the Merrimack estuary as well as to provide some indications of the consequences of various alternative pollution abatement plans on the estuary. However, since it is impossible to divorce the river itself from such an inquiry, at appropriate times reference will be made to the river and its effect on its estuary.

The River System

The Merrimack River Basin is located in central New England, extending southward from the White Mountains in New Hampshire to the northeastern portion of Massachusetts. The drainage area is 5,010 square miles. Of this 3,800 square miles are in New Hampshire and 1,210 in Massachusetts. The population (1960) within the Merrimack Basin is estimated as 1,072,000 of which 747,000 are in Massachusetts and 325,000 are in New Hampshire.

In general the larger towns are located along the river itself which arises from the confluence of the Pemigewasset and the Winnepesaukee Rivers near Franklin, New Hampshire. The trend of the river is southerly in New Hampshire but after entering Massachusetts it turns abruptly East and empties into the Atlantic Ocean at Newburyport, Massachusetts. The last 22 miles are tidal.

The Estuary

The Merrimack Estuary has been identified as that portion of the Merrimack River lying East of 70 55' west longitude (see Figure 1 which reproduces a portion of USCGS Chart No. 213). The maximum length of the estuary is 6.0 nautical miles. The maximum width at high water is 1.6 nautical miles; at low water the maximum width is 0.7 nautical miles. The area of the estuary at mean high water is 3,957 acres; at mean low water the area is 2,110 acres. Thus the intertidal area is 1,847 acres or 46.7% of the total area. A total of 4,208 acres of salt marsh drains into the Merrimack estuary. The total volume of the estuary at mean high water is 1,884,405,600 cubic feet; at mean low water it is 835,829,300 cubic feet. Consequently, the volume of water in the estuary at mean low water is only 44.4% of that in the estuary at mean high water. This relation makes for the very high flushing rate of 56% per tidal cycle. This is a high flushing rate in comparison to other estuaries. The

mean flow of the river is about 15 million cubic feet per day. This only represents about 1.5% of the volume flushed on each tidal cycle, or twice each day. At the time of spring floods the peak flow only amounts to about 5% of the volume flushed on each tidal cycle; at times of minimal flow the river only contributes 0.3% of the volume flushed on each tide. Thus, given the present grossly polluted condition of the river to all intents and purposes the estuary acts like a giant toilet bowl which is flushed twice a day. Thus it is clear that small variations in flow probably will not have any great effect on the distribution of physical properties in the estuary.

A factor which contributes both to the high flushing rate and the high productivity of the estuary is the relative shallowness of the estuary. Approximately 50% of the area of the estuary is less than 5 feet deep at low tide; about 90% of the area of the estuary is covered by less than 18 feet of water at low tide. Light transmission values observed in July, 1971 show that when the bottom is overlain by river water, plants receive sufficient light to grow at a depth of 18 feet. But when the bottom is overlain by ocean water, sufficient light for the growth of plants would penetrate to 60 feet which is deeper than any part of the estuary. Thus between 90 and 100% of the area of the estuary is available for the growth of plants.

A Bit of History

To better understand the present condition of the Merrimack estuary and also to better understand the probable impact of various pollution abatement techniques, it is constructive to look at the past. Settlement of the Merrimack Basin began in the early 17th century with the settlement of the towns at Newbury, Newburyport, and Salisbury. From the first these towns took their sustenance from the vast estuarine fisheries. Salmon and shad were the most important species in these fisheries. As early as 1634 William Wood reported on the outstanding fish populations "in this river of Sturgeon, Salmon, and Bass, and divers other kinds of fish." These anadromous fish which spawned in the upper reaches of the river returned from the sea in vast numbers every year. Great quantities of these fish were used both as food for local consumption and as a produce to be bartered for necessities.

In colonial times the sturgeon fishery was extremely important; it lasted until the late 19th century. The Merrimack was known as one of the two best areas for sturgeon fishing in the colonies. As late as 1887, 4,000 pounds of sturgeon were caught in one week. Two species of sturgeon, the Atlantic sturgeon and the shortnose sturgeon were involved in this fishery.

At the time of first settlement the Atlantic salmon was extremely abundant. So much so in fact that apprentices' contracts

specified that they could be made to eat salmon only three times a week. However, as a result of heavy fishing pressure, the fish became less abundant and were highly prized. The salmon fishery lasted until the first dam on the Merrimack was completed at Lowell in 1847. The last salmon were seen below the dam at Lowell in 1860.

Also in colonial times the Merrimack supported large runs of Blueback, hickory shad, alewife and shad. Of these the alewife and blueback were fished primarily for bait, while the two species of shad were used for food.

In pre-colonial times the Indians resident in the area of the Merrimack estuary used large quantities of the softshelled clam for food. However in colonial times, perhaps because of the great abundance of food fish they were not highly prized as food. There was no outside market for clams. The initial commercial use of clams was their use as bait in the offshore banks fisheries. By 1860 inland markets were opened up for clams as food. There followed a period of intense exploitation as both the food and bait industries competed for clams. Production continued high until the early 20th century when the industry collapsed as a result of over-exploitation. In 1925 the flats were closed to digging as a result of pollution. In 1928 the City of Newburyport opened a clam-purification plant on Plum Island and digging began anew. However by 1945 pollution had increased to the point that almost no clams from the Merrimack estuary could be treated at the plant.

The chronology of the decline of the fisheries in the Merrimack estuary is basically the chronology of the industrialization and population of the river basin. The industrialization of the Merrimack began in the early 19th century when industry was attracted to the Merrimack Valley by the abundant water power available there. The first cotton mill was built just north of where Manchester, New Hampshire now lies in 1800. Between 1800 and 1822 none of the several mills built were successful but between 1822 and 1830 a number of commercially successful cotten mills came into operation. Between 1830 and 1850 the great mill towns of Manchester, New Hampshire; Lowell, Massachusetts; Lawrence, Massachusetts and Haverhill, Massachusetts came into being and grew rapidly.

This period of rapid growth was accompanied by the building of dams for greater use of water power. The first major dam was built at Lowell in 1847; the last at Amoskeog in 1871. In all, six dams were built on the Merrimack River and a further three on the Pemigewasset River. These dams served to completely block runs of anadromous fish on the river. The industrialization of the Merrimack Basin reached its peak in the first part of the 20th century. These industries, primarily cotton and woolen mills, released a very large amount of organic and other waste into the river. In the 1920's and 30's the river was frequently lacking oxygen over large stretches

during the summer months. Older residents of the area have told one of the authors that frequently it was possible to tell what color fabrics were being made on the mills upstream by the color of the river. After World War II the textile industry declined sharply and at present (1971) is not important. Other industries which have far less harmful effect on the river now use the old mill buildings.

At the same time that cotton and woolen business was declining there was a dramatic increase in the population of the Merrimack Basin. Thus, as the volume of industrial waste declined, the volume of domestic sewage increased.

Today

At present (1971) the river receives a relatively small amount of industrial waste. At the same time as a result of population from Amesbury to above Manchester, New Hampshire the river resembles nothing so much as an open sewer. Of all the towns on the river only Newburyport has any sort of sewage treatment facilities and this is only a primary treatment plant. There are instances of coliform counts as high as nine million per 100 milliliter* of river water. (A coliform count of 700 per 100 milliliter is considered to be a symptom of gross contamination with human sewage.) The estuary fares better, presumably as a result of the large flushing ratio and

*A milliliter is one cubic centimeter or about 6 hundredths of a cubic inch, so 100 milliliters is about one half cup of water.

the natural die-off of bacteria. However, the degree of contamination by human sewage in the estuary is enough to close nearly the entire estuary to clam digging. Despite the dilution brought about by tidal flushing of the estuary, the level of incoming contaminants and the concentrating capacity of these filter feeding shellfish account for this unfortunate situation. After all, one percent of 100,000 coliform per 100 milliliter is still a large amount of contamination!

Characteristics of the Estuary

The Merrimack estuary is a typical estuary which is characterized by sharp boundaries between fresh and salt water. During times of high river flow the fresh water flows out over the intruding salt water which thus forms what is called a "salt wedge". At such times the boundary between fresh and salt water, at the surface, may reach as high as the town of Newburyport; the same boundary at the bottom may be much further upstream. When the above condition holds, the estuary is said to be stratified. Under conditions of low flow (less than about 3,000 cubic feet per second - which can occur in late summer and probably in mid-winter too) the tendency for fresh water to override the salt water is much reduced, and the boundary between the two may become nearly vertical. At such times the estuary is said to be non-stratified. Another factor which affects the position of the boundary between the fresh and salt water results from the rotation of the earth. The

effect of this is to tilt the boundary between the fresh and salt water upward toward the right or north side of the estuary. This causes the "ponding of fresh water over Joppa Flat on the south side of the estuary. Sediment falling from this ponded fresh water is probably the reason why Joppa Flat is where it is.

At the front between river water and ocean water, in a distance of less than a meter (approximately one yard) the temperature may change by 10 degrees Centigrade (18°Fahrenheit)* and the salinity may change by as much as $18\ ^{\circ}/_{\circ\circ}$ (parts per thousand). The front itself moves up and down the estuary with the tide. Although there is some mixing between river water and ocean water, it is useful to think of there being two water masses in the estuary whose position changes with the stage of the tide. The physical chemical properties of these two water bodies will be discussed separately.

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*Many people are accustomed to think of temperature in terms of Fahrenheit rather than Centigrade degrees. To make reading easier and to give them a feel for the relationship between these two scales, the centigrade values in the text will not be followed by the corresponding Fahrenheit but a simple conversion table is presented here.

Temperature Conversion --- Centigrade to Fahrenheit

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-1	30.2	6	42.8	12	53.6	18	64.4	24	75.2
0	32.0	7	44.6	13	55.4	19	66.2	25	77.0
1	33.8	8	46.4	14	57.2	20	68.0	26	78.8
2	35.6	9	48.2	15	59.0	21	69.8	27	80.6
3	37.4	10	50.0	16	60.8	22	71.6	28	82.4
4	39.2	11	51.8	17	62.6	23	73.4	29	84.2
5	41.0								

The properties of the ocean water entering the Merrimack estuary probably have not changed much since colonial times or before. The salinity varies from $30^{\circ}/_{oo}$ to $33^{\circ}/_{oo}$ throughout the year; the temperature varies from -1° to 15°C over a year's time. The values for nitrate, nitrite, and phosphate content are comparable with those found offshore in the Gulf of Maine. The dissolved oxygen content of ocean water is always greater than 10. 0 ppm (parts per million). The number of viable fecal coliform bacteria found in the entering ocean water ranged from 15 to 30 per 100 milliliter. While these values are higher than those found at offshore stations in the Gulf of Maine, they fall within the limits set for "clean" water set by the Cooperative Interstate Shellfish Commission. In 1964 the detergent content of the ocean water ranged from 0. 0 to 0. 2 ppm and these also fall well within the 0. 5 ppm limit for drinking water set by the U. S. Public Health Service. No data on the pesticide content of ocean water seems to be available, but it can safely be presumed to be low. All things taken together indicate that the ocean water entering the Merrimack estuary is clean and does not bring in any extra pollution load with it.

The temperature of river water entering the estuary varies with the season. The annual range is from -1°C to 30°C. The mean summer temperature is 23. 9°C. Depending on the state of mixing, the salinity of river water may vary from 0 to $15^{\circ}/_{oo}$. The river water in the Merrimack estuary contains high concentrations of

nutrients and bacteria. All of these are typical of a body of water receiving domestic sewage in large amounts. In addition to these physical-chemical properties, the river water has a less than pleasant odor and color. Furthermore, although the river contains enormous amounts of sludge in its lower reaches arising from human sewage and industrial wastes, none is evident in the estuary. This is clearly a reflection of the estuary's very efficient tidal flushing mechanism.

The values obtained in early July 1971 for the nutrients NO_3, NO_2, and phosphate in the river and the estuary are shown in Table 1. These values show a consistent rise in nutrient content as the river flows past the various cities along its length. The values observed in the estuary are slightly less than those observed at Amesbury, presumably as a result of mixing with the ocean water. These values were obtained at a time of minimal flow so they should be representative of the higher values to be found in the estuary.

At various times in the past the bacterial population of the river water entering the estuary has been determined. Estimates made previous to 1964 when Newburyport began primary sewage treatment are generally higher (49,000 per 100 milliliter and 30,000 per 100 milliliter) than those made subsequently (600-1000 per 100 milliliter July 1971). However, even these later numbers are in excess of most, if not all standards for water use.

A dissolved oxygen content of less than 5.0 ppm is generally considered to be detrimental to fish populations as well as to populations of other organisms. During the period 1936-45 the mean oxygen content of the river above Newburyport was 5.0 ppm with a minimum of 1.0 ppm. For the period 1956-61 the mean oxygen content was 5.0 with a minimum of 2.4 ppm. In 1964 no values less than 5.0 ppm dissolved oxygen were found in the estuary. Thus it appears that, although the total load of sewage carried by the river has increased steadily, the total load of organic material entering the river has decreased.

In recent years interest has focused on the presence of long lived organic compounds in waste-water. Data are available from the Merrimack estuary on the concentration of detergent and pesticide residues. In 1964 the river water had detergent concentrations ranging from 0.1 to 0.5 ppm. These values lie within acceptable limits set by the U. S. Public Health Service. Also it is probable that the concentrations of detergent residues are lower now because of the increase in the use of bio-degradable detergents between 1964 and 1971. In the summer of 1964 DDT, DDE, Dieldren and Heptachlor epoxide were all found in river water at concentrations of 0.001 - 0.003 ppm. At the same time up to 2.80 ppm Heptachlor epoxide were found in clam meats in the Merrimack estuary. However by December 1964 no residues were found in clam meats,

so the concentrations built up in the summer seem to be dissapated during the winter. No data are available on the present concentrations of pesticide residues in the estuary.

On the whole, it appears that the Merrimack estuary may now be in the best condition it has been in the last 100 years*. About 70% of the industrial waste has been removed by the closing of many mills and it appears that pollution with domestic sewage has not yet placed a load on the estuary similar to that existing in the first part of this century. However, with continued population growth, if nothing is done the gains realized in the past two decades may well be lost.

Aesthetics

From an aesthetic viewpoint, the estuary is at present (July,1971) not terribly badly off. The water in the estuary is full of fine particulate material and is of a muddy-brown color, but it has only a slight "swampy" odor which is only faintly reminiscent of the very offensive odors found upstream. The extensive tidal flats do not have an offensive odor at low tide while at high tide the lower reaches of the estuary are quite attractive. These attractive features are evident in the fact that the estuary is heavily used for boating and sport-fisheries. However, it is obvious that removal of the upstream

* The river is so polluted one must really see it to believe it while in contrast the estuary is amazingly good. Here also this remarkable fact must, almost, be seen to be believed.

sewage would enhance the aesthetic attraction of the estuary by removing color, odor and particulate material now found in river water entering the estuary.

The Fisheries

At present the finfish fauna of the Merrimack estuary consists of about 50 species (see Table 2). Of these, seven are basically fresh water fishes; three species are anadromous, i.e. they breed in fresh water but live as adults in salt water, and one species, the Americal Eel, is catadromous, that is they spend their adult life in fresh water and breed in salt water. There is no indication that populations of any of the non-migratory fish are being affected adversely by either the up-river pollution, or pollution within the estuary.

There are well developed sport-fisheries for the mackerel, striped bass, and many of the species of bottom fish. This sport-fishery was worth about one million dollars annually to the Newburyport area in 1964.

Commercial fisheries existed for only three species of fish in 1964. Approximately 178,000 pounds of striped bass were sold for about $44,500 in that year. One of the other important fisheries is that for American Sand Lance or Sand Eels for use as food and as bait. Approximately 1,400 barrels of these fish worth $14,000 were captured in 1964. Also in 1964 about 3,000 pounds of

American Eels were taken from the Merrimack for use as food and bait. This catch of eels was worth about $500. It is certainly a sad commentary on the present state of the commercial fishery in this estuary which once teemed with valuable fish that its products were in 1964 only worth a total of $78,000 for a whole year's effort!

Except for the American eels, there is no commercial fishery for any of the migratory fish which were the mainstay of the fisheries in pre-industrial times. Populations of such migratory fish as the American eel, the blueback herring and the alewife have been decimated by the construction of dams upstream and by the appalling condition of the river upstream of the estuary. The entire population of such valuable fish as the Atlantic salmon, the shad, the hickory shad, and the sturgeon have been extirpated by the combination of upstream pollution and dams. As a result, the sport and commercial fisheries must subsist on such predacious oceanic fish as are attracted to the estuary by the vast numbers of bait-fish which live there. As good as the fishing may seem to us now, it is only a shadow of its former glory.

Other than these species which are important as food or bait, very little is known about the burrowing and bottom-dwelling fauna of the Merrimack estuary. Oxygen levels are relatively high above the sediment-water interface, so there is no reason to believe that benthic invertebrate fauna should be radically different from that of other similar estuaries. However, the sediments throughout the

estuary are anoxic as a result of the deposition of the large amount of organic material carried by the river. As a consequence, they are characterized by a hydrogen-sulfide odor. This lack of oxygen in the sediments combined with the relatively harsh oceanographic environment limits the population to those species which are very tolerant of changes in temperature and salinity and which do not rely on oxygenated water in the sediments to survive. As a result, the macroscopic fauna is quite limited.

The most common macroscopic invertebrate in the estuary is the softshell clam. Associated with the softshell clam is the clam worm, the blood worm, the duck clam, and the blue mussel. There is virtually no harvest of softshelled clams, the only commercially important species present, because of contamination of the beds with sewage. However as many as 100,000 bushels of softshell clams peryear could be harvested from the flats of the Merrimack estuary. It is estimated that the potential harvest of softshell clams could be worth between \$500,000 and \$1,000,000 annually to the Newburyport area. This positive impact of pollution abatement would create an industry as large as the sport-fishing industry and would yeild a tremendous benefit to the area.

A list of the important species of plants found in the Merrimack estuary is given in Table 3. The species are important in two ways to the animals living in the estuary. First, they provide

shelter for the young of many species of fish and thus contribute to the importance of estuaries as fish nurseries. The second way these plants are important to estuarine animals is that they provide a large quantity of food, both directly and in the form of nutrients which enrich other areas of the estuary. There is no evidence that the plant population of the Merrimack estuary is adversely affected by the pollution of the Merrimack River. On the contrary, the plants living in the estuary very probably benefit from the presence of nutrients brought into the estuary by the river.

The Waterfowl

The Plum Island marshes and waters of the Merrimack estuary are renowned for the concentrations of marsh birds, shore birds and waterfowl that are found there. Gunning for waterfowl has been practiced there since colonial times, and in recent years it has been a favorite spot for bird-watchers and students of ornithology. These waterfowl populations constitute approximately eight percent of the state's coastal waterfowl wintering populations. The major species inhabiting the marshes and bays of the estuary are listed in Table 4 by categroies; i.e., geese, sea ducks, dabbling ducks, diving ducks. The data represent average values for the five-year period 1965 through 1969. Under the "Remarks" column information on feeding habits and feeding area preferences are presented. Species counts are taken each year by the Massachusetts Department of Natural

Resources in January via aircraft at elevations of 200 to 400 feet. They represent trends in abundance and not total numbers. Data from band recoveries indicate the counts may be only one-third to one-quarter the total number of birds present on a given area.

Extensive areas of excellent nesting habitat for marsh birds and some waterfowl species exist despite the encroachment of man. Thousands of ducks and geese winter in the area, but the largest numbers of birds are present during spring and fall migrations when flights of ducks and geese are passing through and hordes of sandpipers and plovers scour the tidal flats feeding on tiny marine organisms.

The present level of pollution in the Merrimack River has had little direct effect on these groups of birds although it has affected many of the animals and plants upon which they feed. The survival of fish and shellfish larvae has been reduced in the areas of heavy pollution in the river whereas some of the pollutants have served to nutrify the marshes around the river mouth.

A reduction in the amount of pollution in the river will increase the survival of fish and invertebrates spawning there and will probably lead to an increase in the numbers of diving ducks frequenting the river. Increased survival of small invertebrates in the mud of the tidal flats near the river mouth will attract even greater numbers of shorebirds to the area during migration. The general effect of reducing pollution in the Merrimack River will be beneficial

to the water bird populations of the area.

Pollutant Removal Implications

The major beneficial effect of removing pollutants from the Merrimack River water entering the estuary would be twofold. First, the aesthetic value of the estuary would be visibly enhanced. This would very likely lead to an enlargement of the recreational fishing and boating industry. Because this industry is already worth about $1 million to the Newburyport area, any significant increase would be a boon to the area. The second major beneficial effect would be to recreate a major clamming industry of considerable value as mentioned above.

However, these benefits, great as they are, are far over-shadowed by the potential benefits accuring from the building of adequate fish-ladders around the dozen or so dams across the Merrimack, Pemigewasset, and Winnepesaukee Rivers. A fish ladder already exists around the dam at Lawrence. However, its design leaves a lot to be desired in that smaller upstream migrants such as eels have to make jumps of 1 1/2 to 2 times their body length in order to pass up. In late June 1971 when one of the authors visited the fish ladder, young eels 2-4" in length were attempting to migrate up the ladder. Their efforts were being largely frustrated by poor design, an inadequate flow of water, and the presence of

floating debris in the ladder. It was a sad sight to see these little fish which had traveled thousands of miles from their spawning grounds in the Sargasso Sea being frustrated in their attempts to migrate upriver. If these dams were no longer to act as barriers to migrating fish, there appears to be no reason why the river should not support the runs of anadromous fish that it once did. Enhancement of the runs of alewives and blueback herring should increase the already large numbers of bait fish in the estuary. These, in turn, should attract more game fish. While the alewife and the blueback are not prized for food, the shad is. It should not prove too difficult to re-establish shad runs once adequate fish-ladders were built. Once shad runs were developed a valuable commercial and sport fishery would surely come into being. It may prove more difficult to reintroduce the sturgeon. However, populations of sturgeon exist in the adjacent Parker River Estuary. Thus natural re-introduction should follow the cleaning up the river.

A more ambitious program of introduction of fish species that could bring great rewards would be to introduce one or more species of Pacific salmon. The most successful introductions of the Pacific salmon have used either the Coho or the Pink salmon. Both of these species are valuable commercially. The commercial benefit of these species would be enhanced by the fact that salmon can be fished for successfully with little or no greater investment than that required for a lobster boat. In addition, a successful run of Coho salmon would create an extremely valuable sport-fishery

throughout the Merrimack Valley.

Once the river is cleaned up, the potential exists for any of the above programs. Their cost should be weighed against the benefits that could be realized. The introduction of any of the species mentioned would create a valuable sport fishery as well as a valuable commercial fishery. The commercial fisheries would be such that they could be entered with a minimum of investment on the part of the fisherman and the sport fisheries would provide a much needed recreational resource for the 10 million or so people who live within one day's drive of the Merrimack Valley. Many of these 10 million people might not otherwise have the opportuntiy for such high-quality recreation. It seems that this river lying as close as it does to the major population centers of the northeast, offers a fine chance to develop a magnificent recreational resource for use by a very large number of people. Once the Merrimack is an asset rather than a liability, it should be easier to attract non-polluting sorts of industry to the valley.

One possible major harmful result of cleaning up the estuary is that shellfish predators which presently are absent from the estuary may be able to invade the estuary in the absence of pollutants. Such predators include the horseshoe crab, the green crab, the moon snail, the knobbed and channeled whelks, as well as various species of starfish. At present not enough is known about the

reactions of these species to the pollutants found in the Merrimack Estuary to predict whether they will become troublesome in the absence of pollution.

Another possible adverse effect of pollution abatement procedures is that the productivity of the estuary might be reduced as a result of the reduction of the nutrient levels in river water entering the estuary. This is a legitimate source of concern. However, the input of river water itself is relatively small. At the same time, the estuary is believed to derive the largest part of its nutrients from the surrounding salt marshes rather than from the river water entering the estuary. Therefore it does not appear that any appreciable reduction in productivity would follow on reducing the nutrient load carried by the river water.

Wastewater Management Plans

Now that the present and possible future conditions of the Merrimack estuary and its ecosystem have been described, it is possible to evaluate the impacts of various wastewater management schemes on the estuary. The first such scheme to be evaluated (Plan A) is one which would remove all pollutants from the river and which would not divert any river water.

The prime effects of such a scheme on the Merrimack estuary have, in effect, been described above. It would be to create

a major new industry, that of clamming, worth about $1 million. It should require no more than one year from the date of diversion of all pollutants to realize the full benefit of this impact. Subsidiary effects would be to enhance the pleasure-boating-sport-fishing industry. This later positive impact of pollution abatement should be realized almost immediately after diversion of all pollutants. Such a plan would also open the way for the creation of a number of valuable sport and commercial fisheries via the establishment of runs of anadromous fish such as shad, salmon and sturgeon. Such a program would however, in addition, require the construction of fish ladders around the dozen or so dams that currently block the river upstream from the estuary. However, the benefits to be realized would be many times greater than those realized by simply cleaning up the river.

The removal of pollutants from the estuary could possibly have an adverse effect in that shellfish predators such as the above mentioned whelks, snails, and crabs, not now found in the estuary might be able to invade and prey on the clam flats. However, even if these predators do come in after cleansing of the river, their presence should not be crippling to a properly managed clam flat. Another possible adverse effect would be that the productivity of the estuary might be reduced because of a reduction in the nutrient supply. However, because the estuary is believed to derive most of its

nutrients from the extensive surrounding salt marshes no significant decrease in the productivity of the estuary is expected.

On the whole, because the estuarine ecosystem does not appear to be under any great stress from pollution, the changes ensuing on removal of that stress are expected to be minor.

The second wastewater management plan (Plan B) to be considered is identical with the first except that about 500 million gallons of water per day will be diverted from the river. This represents about 0.5 to 2.0% of the daily water flow in the river. No appreciable change in the impact presented for Plan "A" is expected.

The third wastewater management scheme to be considered (Plan C) is similar to Plan B except that between 250 and 500 million gallons per day will be diverted from the river at all times. Since it is difficult to obtain estimates of low flow rates for the Merrimack it is not possible to estimate the percentage of water which could be diverted under this scheme. However, there is no doubt that it would be a very large percentage at times of low flow. It appears that this procedure would virtually halt freshwater flow into the estuary at times. Also it would have strong adverse effects on upstream fish populations including the young of anadromous fish. For this reason, adoption of Plan C is strongly discouraged.

Needed Information

During the researching for this report a number of areas

in which knowledge was lacking became apparent. First, there do not appear to be any reliable data on the temperature and salinity tolerances of a number of shellfish predators that might invade the Merrimack estuary in the absence of pollution. Likewise, there are no data whatever on these species responses to various pollutants. Also, research should be initiated into the physiological tolerance of various wood-boring organisms which might invade the estuary subsequent to its cleansing. There do not appear to be any data available on the rate at which a grossly polluted clam flat can cleanse itself. Knowledge of this type is vital to assess the effects of various pollution abatement programs both in the Merrimack estuary and other places.

Also there are no data on the concentrations of toxic ions either in the estuary, the river sediments or organisms inhabiting the estuary. This sort of data should be available before an estuary, which has received as much industrial waste as the Merrimack estuary has, can be declared clean.

If runs of anadromous fish are to be maintained in the river as pollution abatement becomes operative, and if at the same time water is to be diverted from the river, extensive research into the effects of river flow rates on river temperature will be required. Yearly temperatures and flow records at a number of points along the River will be required in order to insure that the river temperature

does not exceed the lethal limits of young or adult anadromous fish while they are in the river.

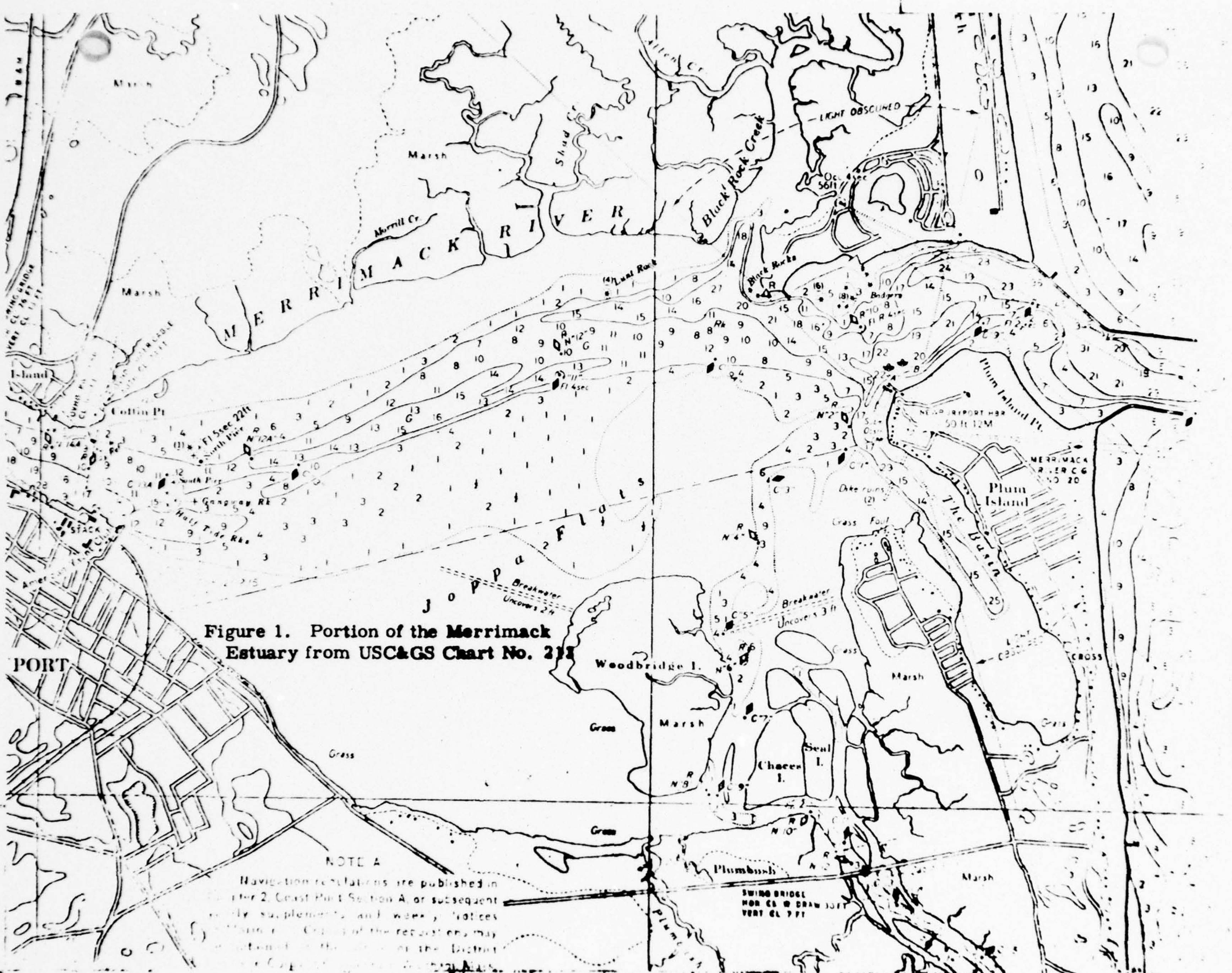

Figure 1. Portion of the Merrimack Estuary from USC&GS Chart No. 21

TABLE 1: Nutrient Content of Water

Samples Taken at Various Locations on June 27, 1971

Location	NO_3	NO_2	PO_4
	(in microgram atoms per liter)		
Plymouth, New Hampshire	8.00	0.10	0.08
Above Manchester, New Hampshire	2.48	0.23	0.32
Nashua, New Hampshire	10.43	0.77	2.05
Lowell, Massachusetts	17.14	1.58	1.79
Lawrence, Massachusetts	24.75	3.45	3.42
Haverhill, Massachusetts	30.80	4.50	4.65
Groveland, Massachusetts	30.35	4.55	6.16
Amesbury, Massachusetts	27.80	4.40	1.94
Estuary in River Water	24.50	2.60	3.15
Estuary in Ocean Water	0.83	0.42	0.75
Gulf of Maine Surface Water	0.06	0.10	0.20
Gulf of Maine Deep Water	3.5	0.30	0.60

TABLE 2: Finfish of the Merrimack Estuary

From
A Study of the Marine Resources of the Merrimack River Estuary*

by

W. C. Jerome, Jr., A. P. Chesmore,
C.O. Anderson, Jr., and Frank Grice

Class: CHONDRICHTHYES

- **Order**: Squaliformes (Sclachii)
  - **Family**: Squalidae — dogfish shark
    - *Squalus acanthias* — spiny dogfish
- **Order**: Rajiformes (Batoidei)
  - **Family**: Rajidae — skates
    - *Raja binoculata* — big skate
    - *Raja erinacea* — little skate
    - *Raja laevis* — barndoor skate

Class: OSTEICHTHYES

- **Order**: Clupeiformes (Isospondyli)
  - **Family**: Clupeidae — herrings
    - *Alosa aestivalis* — blueback herring
    - *Alosa pseudoharengus* — alewife
    - *Clupea harengus harengus* — Atlantic herring
  - **Family**: Salmonidae — trouts
    - *Salmo trutta* — brown trout
  - **Family**: Osmeridae — smelts
    - *Osmerus mordax* — American smelt
- **Order**: Cypriniformes (Ostariophysi)
  - **Family**: Cyprinidae — minnows and carps
    - *Cyprinus carpio* — carp
    - *Notemigonus crysoleucas* — golden shiner
    - *Notropis hudsonius* — spottail shiner
  - **Family**: Catostomidae — suckers
    - *Catostomus commersoni* — white sucker
  - **Family**: Ictaluridae — freshwater catfish
    - *Ictalurus nebulosus* — brown bullhead
- **Order**: Anguilliformes (Apodes)
  - **Family**: Anguillidae — freshwater eels
    - *Anguilla rostrata* — American eel
  - **Family**: Congridae — conger eels
    - *Conger oceanicus* — conger eel
- **Order**: Cyprinodontiformes (Microcyprini)
  - **Family**: Cyprinodontidae — killifishes
    - *Fundulus heteroclitus* — mummichog
- **Order**: Gadiformes (Anacanthini)
  - **Family**: Gadidae — codfishes and hakes
    - *Gadus morhua* — Atlantic cod
    - *Melanogrammus aeglefinus* — haddock
    - *Microgadus tomcod* — Atlantic tomcod
    - *Pollachius virens* — pollock
    - *Urophycis chuss* — squirrel hake
- **Order**: Gasterosteiformes (Thoracostei, Hemibranchii, Lophobranchii, and Solenichthyes)
  - **Family**: Gasterosteidae — sticklebacks
    - *Apeltes quadracus* — fourspine stickleback
    - *Gasterosteus aculeatus* — threespine stickleback
    - *Pungitius pungitius* — ninespine stickleback
  - **Family**: Syngnathidae — pipefishes and seahorses
    - *Syngnathus fuscus* — northern pipefish
- **Order**: Perciformes (Percomophi; Acanthopterygii)
  - **Family**: Serranidae — sea basses
    - *Roccus americanus* — white perch
    - *Roccus saxatilus* — striped bass
  - **Family**: Centrarchidae — sunfishes
    - *Lepomis gibbosus* — pumpkinseed
    - *Lepomis macrochirus* — bluegill
  - **Family**: Percidae — perches
    - *Perca flavescens* — yellow perch
  - **Family**: Scombridae — mackerels and tunas
    - *Scomber scombrus* — Atlantic mackerel
  - **Family**: Cottidae — sculpins
    - *Hemitripterus americanus* — sea raven
    - *Myoxocephalus aeneus* — grubby
    - *Myoxocephalus octodecemspinosus* — longhorn sculpin
  - **Family**: Cyclopteridae — lumpfishes and snailfishes
    - *Cyclopterus lumpus* — lumpfish
    - *Liparis atlanticus* — seasnail
  - **Family**: Ammodytidae — sand lances
    - *Ammodytes americanus* — American sand lance
  - **Family**: Pholidae — gunnels
    - *Pholis gunnellus* — rock gunnel
  - **Family**: Stichaeidae — pricklebacks
    - *Ulvaria subbifurcata* — radiated shanny
  - **Family**: Zoarcidae — eel-pouts
    - *Macrozoarces americanus* — ocean pout
  - **Family**: Atherinidae — silversides
    - *Menidia menidia* — Atlantic silverside
- **Order**: Pleuronectiformes (Heterosomata)
  - **Family**: Bothidae — lefteye flounders
    - *Paralichthys oblongus* — fourspot flounder
    - *Scophthalmus aquosus* — windowpane
  - **Family**: Pleuronectidae — righteye flounders
    - *Glyptocephalus cynoglossus* — witch flounder
    - *Hippoglossoides platessoides* — American plaice
    - *Limanda ferruginea* — yellowtail flounder
    - *Liopsetta putnami* — smooth flounder
    - *Pseudopleuronectes americanus* — winter flounder
- **Order**: Lophiiformes (Pediculati)
  - **Family**: Lophiidae — goosefishes
    - *Lophius americanus* — goosefish

*Monograph Series No. 1, Division of Marine Fisheries, Department of Natural Resources, The Commonwealth of Massachusetts, June 1965.

TABLE 3: All Species of Flora

Collected and Identified

by

W. C. Jerome, Jr., A. P. Chesmore,

C.O. Anderson, Jr., and Frank Grice*

Scientific Name	Common Name
ALGAE	
Class: CHLOROPHYCEAE	GREEN ALGAE
Chaetomorpha sp.	
Derbesia vaucheriaformis	
Enteromorpha mathinata	
Monostroma sp.	
Ulothrix flacca	
Ulva latuca	sea lettuce
Class: RHODOPHYCEAE	RED ALGAE
Chondrus crispus	Irish moss
Phycodrys rubens	
Class: PHAEOPHYCEAE	BROWN ALGAE
Agarum cribrosum	holed kelp
Ascophyllum nodosum	rock weed
Desmarestia aculeata	
Fucus spiralis	rock weed
Fucus vesiculosis	rock weed
Laminaria saccarina	kelp
VASCULAR PLANTS	
Acorus calamus	sweet flag
Artemisia stelleriana	dusty miller
Eleocharis sp.	spike rush
Lythrum salicaria	swamp loosestrife
Pontederia cordata	pickerel weed
Sagittaria latifolia	duck potato
Scirpus americanus	three square bull rush
Scirpus validus	soft stem bull rush
Spartina alterniflora	salt water cord grass
Spartina patens	high water cord grass
Spartina pectinata	fresh water cord grass
Zizania aquatica	wild rice

*From "A Study of the Marine Resources of the Merrimack River Estuary", Monograph Series No. 1, Division of Marine Fisheries, Department of Natrual Resources, The Commonwealth of Massachusetts, June 1965.

TABLE 4: Numbers and Fee[illegible]ng Characteristics of Waterfowl Species Frequenting the Merrimack River Estuary During the Fall and Winter

Species	1965-1967 Average Number	Range	Remarks: Feeding Habitat	Remarks: Ratio Animal:Vegetable	Remarks: Major Plant and Animal Typ[illegible]
Geese:					
Canada Goose	230	92-560	Salt marsh, shallow creeks and flats, primarily along west side of Plum Island.	Tr.:99+	Cordgrass, widgeongrass, sea lettuce, naiad, glasswort, eelgrass, saltgrass, bulrush
Dabbling Ducks:					
Black Duck	8,882	6,800-10,110	Salt marsh, shallow creeks and flats to a depth of about 3 feet; primarily around Woodbridge Island, Joppa Flats, and west of Plum Island	50:50 (in late winter the diet may be almost entirely animal	Mollusks (mostly univalves), crustaceans, immature form[illegible] of aquatic insects. Speci[illegible] taken include Mya arenia, Hydrobia sp., Mytilus edali[illegible] Gemma gemma, Neeris sp., Melampus bidentatus, Litto[illegible] sp., and Gammarus. Plants i[illegible]clude cordgrass, widgeongra[illegible] eelgrass, arrowgrass, and wi[illegible] [illegible]
Diving Ducks:					
Bufflehead and Goldeneye (counts combined)	1,035	400-1,900	Bays, deep rivers to depths exceeding 30 ft; locate in Newburyport Harbor and open water areas of Plum Island Sound.	80:20 (both species)	Bufflehead: insects, mollus[illegible] (mostly univalves), naiad, widgeongrass. Goldeneye: crustaceans (5[illegible] cent crabs), insects, some mollusks and fishes, widge[illegible]grass, eelgrass.
Scaup	1,060	100-3,800	Same as above	50:50	Mollusks, larval insects, amphipods, crabs, barnacles, eelgrass, pondweeds.
Sea Ducks:					
Scoters	312	0-550	Offshore on shoal areas and in deep bays; primarily at the Merrimack jetty and north of Woodbridge Island	94:6	Both species: mussels, bar[illegible]acles, insects, fishes, echinoderms, eel[illegible], kelp, muskgrass, wid[illegible]. Vegetable matter may compris[illegible] about 21percent of diet in [illegible] fall.
Eiders	46	0-125		94:6	

* Personal Communication, Warren W. Blanden, Chief of Wildlife Research, Massachusetts Department of Natural Resour[illegible]

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Report to the Army Corps of Engineers

On The Merrimack River Waste Water Pilot Project

THE SOCIAL-INSTITUTIONAL IMPACTS

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May 1971

The charge given to the group was to "push the limits of technology". This is a bold charge, but one that has been made and implemented far too often during the past century. In a very real sense are not such statements a reflection of the environmental problems facing the Nation today? Has not "technology" pushed the limits of environmental acceptance already? Is it not "technology" that has made the waters of the Merrimack Basin little short of open sewers? Applied technology has solved few problems without creating others of equal or greater magnitude.

Pushing technology to its limits without an equal understanding of ecological, cultural and institutional limits will not solve problems. One of the strongest forces emerging in the Nation today is the fundamental questioning of the long term merits and effects of technology. Congress gave full recognition to this in its recent deliberations and vote regarding future funding of the S.S.T. The public expressed itself on this matter on Earth Day in 1970 and Earth Week in 1971. It is apparent that environmental problems can no longer be brushed aside by token gestures.

The point to be made here is the emphasis that the Corps seems to be placing on a technical solution to the Merrimack River Basin in its feasibility investigation. While it is obvious that technology must be developed and applied to the water quality problem, it is abundantly clear that non-technological problems

must receive equal and perhaps more attention. As stated in the introduction of, A Pilot Wastewater Management Program (March 1971), "A basic problem is the almost total reliance on plan formulation at the local level...No adequate institutional structure and capability exists to assure that alternative regional systems will be prepared." This is just one of the many institutional problems that must be solved in the Study Basin before real technological progress towards water quality improvement can be obtained.

All the technological solutions introduced by consultants at the May meeting, if applied to the basin will require varying degrees of inter-governmental cooperation on a regional basis. Traditional Corps feasibility studies have focused largely on the engineering feasibility with comparatively little study of the social and institution feasibility. It is suggested here that even more effort be shifted at this very early study stage to the institutional feasibility and implication. Asking three consultants to spend two weeks each on separate aspects of these problems hardly represents equal effort as compared to what has been applied to the technological side of the problem.

On a National basis, public opinion is quite ready to support the Corps in a more aggressive role towards the solution of ecological, cultural and social implications of proposed technical solutions. It is disappointing that this has not been done in

the case of this innovative pilot program.

An analysis of the non-technical problems of waste water disposal in the Merrimack basin should be studied on a parallel basis with the technical problems. The same degree of competence, skill and imagination used so successfully by the Corps to solve engineering problem must be brought to bear on the social and cultural problems. Anything less than this will not be in the best interest of the Basin or the Nation.

Specific Observations & Comment

The general level of detail and tentative nature of the alternative proposals suggested for the Study Basin make it difficult as well as unrealistic to discuss the possible institutional impacts in other than equally general terms.

The study suggests two very broad, yet quite distinct techniques for waste water disposal. One is by various non-traditional methods of land disposal and the other, by several advanced means of water treatment. In the following pages these are briefly discussed as to some of their possible institutional impacts. This is followed by a sub-regional breakdown within the basin in so far as it is meaningful for each of the suggested alternative disposal techniques. Several institutional impacts, however, appear to be common to both major categories of disposal techniques.

Whether disposal is done by water or by land, substantial cooperation

and coordination at local levels of government must be accomplished. This is not an easy task, particularly in New England where the town form of government is strong. The implications of this are clear. Either intergovernmental cooperation is brought about through an extensive (and imaginative) public educational program throughout the Study Basin or legislation requiring such cooperation must be worked through appropriate decision making bodies.

The employment of land disposal methods will necessitate a greater degree of inter-governmental cooperation than is likely to be true with disposal by water treatment plants. However, there will be variations in needed cooperation in either of the two general methods and also within the specific techniques finally adopted.

For example, the overland flow method of land disposal would involve an extremely large amount of land area, probably scattered in different locations and involving many units of local government. On the other hand any combination of water disposal techniques, require comparatively small acreage in perhaps not more than a maximum of a half dozen locations.

Another impact likely to emerge and common under either method, concerns those industries and units of government now comprising the major sources of pollution. Much of the study basin does not at the present rest on a strong economic base. Several of the major industries are not now economically strong, nor is there

much indication that their situation is likely to change for the better in the decades ahead. If additional costs for primary treatment are to be assumed by the individual firms involved, one can safely predict that a number of local firms will close. This can have strong public and political overtones and should be carefully studied on a firm by firm basis.

A similar situation will exist in many of the smaller units of government. Property taxes throughout the Basin are already high. Local governments in many cases will find it difficult to produce the needed additional revenue for primary treatment even if beneficial cost-sharing is available, and costs of advanced treatment could still further aggravate the situation.

Changes in the value of land abutting the Merrimack River may occur as a consequence of the improvement in water quality. If this should happen, then some increase in the local tax base will result, but it is doubtful that this new source of income to local governments will be sufficient to meet the new costs of waste water disposal.

An important question is how land use along the river and its major tributaries may be effected by the project. A study should be made of possible land use change that might be expected, and how, if desirable, these may be controlled and regulated.

Recreation use of various types on and along the main river is

a most likely possibility. How and what kind of facilities should be developed, and who will do this (public, private or a combination) can have a strong economic and social impact in the Study Basin. The topic needs careful consideration as the planning stages advance. Properly worked out, water based recreational activities within the Basin could strengthen the already established tourist and second home industries of the upper portions of the Basin. This would be particularly true in the Lake Winnepesaukee sub-region, long used as a vacation area for the metropolitan regions to the south around the greater Boston area.

Specifics Disposal Techniques

Water Disposal

At the present stage of planning as set forth by the consultants, there do not appear to be many unique institutional impacts peculiar to the different water disposal techniques suggested for the various sub-regions. Whether treatment is by physical-chemical, biological or a mixture of these, the impact would be quite similar to that of any major investment and land use change. For example, changes up or down, in land values in areas adjacent to the installation are to be anticipated along with local citizen support and resistance to these changes. It is quite possible that minor impacts will result in association with zoning regulations, particularly in the lower reaches of the Basin.

The specific locations of water treatment return, will undoubtedly

have a bearing on which segments of government in the Basin will actively support the program. Certainly if the water, once treated, is released outside of the Basin, regional resistance is likely to be of a much stronger nature than if it is returned directly back into the Merrimack. Consideration of the water return points should also be given regarding its effect on the potential of attracting new industry into the Basin which may be drawn by the availability of high quality water.

Thus under the various water disposal systems both the location of treatment and the points of discharge are factors having the greatest potential institutional impact other than the over-all costs. These should receive study both from the economic and the political viewpoint. This applies for each of the sub-regions as well as the Basin itself. It should be anticipated that alternative locations could produce substantial differences in their impacts on local economies.

Land Disposal

The three alternatives of land disposal offer more distinct institutional impacts than is true for water disposal. However, where this is done, ie in or out of the Basin, will pose somewhat similar impacts as those mentioned in connection with water disposal. Thus the locational impacts of the two methods may well be studied at the same time.

Irrigation and overland flow disposal will both involve large land areas and large winter water storage areas. Public education towards the acceptance of either of these methods will be required. More involvement with the private sector is called for with these alternatives than with any of the others suggested. Though few details were presented by the consultants it is also apparent that more local government cooperation will be necessary to meet the demands of either of these land disposal alternatives. As mentioned above, because of strong tradtional ties to town systems of government this will be more difficult to develop than would be the case in other parts of the country. However, if the Basin towns can be shown that there will be a distinct advantage to them, there is little reason to feel that agreements could not be reached. Public education on a large scale therefore will be essential.

Winter storage of the waste water for either of these methods is going to pose impact problems of a most difficult nature. No town or group of towns is going to be happy about storing the waste from cities during the winter months. If there were larger public land holdings within the Basin, perhaps storage would be possible, but other than Fort Devens these do not exist. And Fort Devens is not in an optimum location for the purpose of collection or recharging high quality water to the Basin.

Whether or not any of the land disposal methods offer opportunities

for the development of new forms of agriculture or forestry, is a question that needs study. A short growing season may pose some limitation but the development of specialized crops might be a possibility if the economics of waste distribution can be worked out for private lands.

The flooding basin approach will have many of the same institutional impacts as the two other alternatives, but in some respects would tend to concentrate the question of local government acceptance and cooperation into a few specific areas. There is no question that local public resistance would be strong since land values would be adversely affected.

On a sub-regional basis the various alternatives, either land or water, will present different social, economic and institutional impacts. The extremes clearly are between the more rural region of Lake Winnepesaukee and the urban Boston Metropolitan region.

If one discounts for the moment the dollar costs of any of the alternatives, inter-regional cooperation will be the greatest need and will carry the greatest future impact. For example, New Boston, N.H. is not likely to welcome out of hand huge quantities of waste water from Lawrence or Boston, without first being assured of some economic gain to its local government. Local resistance to land disposal will be greater because the technique involves "spreading the sewage all over the land". Whereas with water treatment most of the process is confined in a large building or two.

Though large metropolitan governments are hard pressed for money, the economic impact of the proposed project will be less in the Boston sub-region than is probably the case for the other sub-regions. The validity of this assumption, however, will depend largely upon what techniques are decided upon and whether or not and where the treated water is returned to the river within the sub-region.

At this stage of preliminary planning it is logical to assume that additional economic impact will result from the employment of operation and maintenance personnel for the system, but it is not possible to speculate on the magnitude until the various alternatives are decided upon. Because of the present population sizes of each sub-region, it is clear, however, that given the same disposal techniques, thus the same number of new jobs for each sub-region, the impact will be greatest in the Lake Winnepesaukee region because of its smaller labor force.

Summary & Conclusion

The kinds and extent of institutional impact caused by the proposed pilot program for the Merrimack Basin will depend to a great extent upon which of the alternative techniques are applied. At the present planning level only the most general kind of speculation is warranted. Never-the-less several comments can be made that will be useful to consider as the planning process proceeds.

1) Early and aggressive study of the non-engineering and

non-technical aspects of the project should be pursued by the Corps. These studies should be done at the same time and should be treated with the same importance as the technical studies.

2) Though the public will probably be more intrigued by the land disposal concept (and its "recycling aspect") more institutional impacts are likely to be associated with this alternative than with water disposal.

3) The greatest institutional impact of the project regardless of the disposal methods adopted will be in the realm of inter-governmental regional cooperation and coordination.

4) An early public education program will be called for in order to develop needed local understanding and support of the project.

5) The economic impact of the project can be substantial, both in terms of benefits and cots to the Basin and its sub-region. Shifts in the kinds of industry within the Basin may be one result. Certainly recreation and tourist activity will be enhanced particularly in the Lake Winnepesaukee sub-region, and to a somewhat lesser extent in the lower two regions.

6) There will be great variation in the institutional impacts, depending upon whether or not treatment is done within the Basin (particularily land disposal) and whether or not the treated water is returned to the Basin and at what specific points along the river.

7) There is a slow, yet constant growth of regional organiza-

tions throughout the New England area. Properly worked with and fostered this movement can be of major importance in realizing the project's objectives.

8) Careful consideration of an "advocacy approach" to the <u>entire</u> planning process should be given. If applied this should involve people (perhaps in substantial numbers) from <u>all</u> levels of government and major citizens interest groups. It should be initiated at the earliest possible time, as a means of gaining local understanding and support.

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IDENTIFICATION AND ASSESSMENT OF ECONOMIC IMPACTS

Merrimack Basin
Wastewater Management Study

Submitted to:
U.S. Army Corps of Engineers

July 16, 1971

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1.0 INTRODUCTION

This study is aimed at identifying, and whenever possible, quantifying the economic impacts of several alternative water management programs for the Merrimack River Basin. Section 2.0 deals with the agriculture of the basin and possible impacts there. Section 3.0 considers manufacturing, while Section 4.0 calls attention to other, less significant impacts which should be explored in detail during survey/scope.

It goes without saying that the objective is much too ambitious in light of the severe limitations of time and effort available for this study. The problems involved in projecting the base line itself (that is, projection of the economic development of the basin) are enormously complex, and have received considerable attention from economists associated with the States of New Hampshire and Massachusetts. Under the limitations imposed on this study, we have not even been able to thoroughly survey the results of existing work; that task alone would take several weeks of intensive effort. Nevertheless, we have relied heavily on projections prepared by various agencies and universities wherever information was available.

If the base line projections are rough, the impact projections are still less precise. As of this writing, there has been no similarly comprehensive water management program tried in the United States. Parts of the proposed system (especially land disposal) have been tried at best on a small scale for short periods of time, usually under quite different conditions of soil, climate, land use, and regional economy. Thus, there is very little hard experience to guide us in assessing impacts. In short, the error ranges around the estimates are quite broad, and a great deal of work will be necessary before we can reach satisfactory levels of confidence in the forecasts.

The fact that this report deals strictly with the economic side of the program cannot be overemphasized. The problem of pollution is due precisely to the fact that the marketplace has not established a price for clean air, clean water, etc., and consequently, the resources have been used (and used up) as if they cost nothing. As long as we deal with present markets and the present economy which treats resources as free goods, no

profit computation will indicate a need to conserve the resources we have at our disposal. Quite obviously, this does not mean that it is unnecessary to do so. But the full picture simply cannot be generated from economic data. Factors of general health, future prosperity, and the quality of life are of prime importance in policy making -- these factors comprise the other side of the equation. Economists have long recognized that these particularly important variables, called "externalities" in the jargon, are usually not valued by the conventional price mechanism of a private enterprise economy.

In light of the above, all the conclusions of this study represent but one side of the picture, that side which can be measured by the conventional price mechanism. For example, our results seem to indicate that land disposal of waste water raises serious doubts as to profitability in the Merrimack Basin. This evidence, even if confirmed by more detailed analysis, is not sufficient to dismiss the question of land disposal altogether. The final decision will have to include the consideration of ecological, aesthetic, and sociological balance sheets as well. Moreover, in this analyst's opinion, the decision will not be made easier if all other aspects are translated into economic terms, i. e., dollars. On the contrary, that simplification may obscure some of the deeper issues underlying the policy choices to be made. The problem of the environment is a multi-dimensional one, and we must face openly the complexity of the decisions ahead. In a technical sense, these decisions must be made over lexicographic rather than continuous utility maps; that is, we have to first make the choice to reach a generally acceptable standard of environmental quality, and move to finding a cost-minimizing solution only as a second step.

2.0 AGRICULTURE AND POTENTIAL IMPACTS

2.1 General Economic Profile of the Merrimack River Basin

The Merrimack River Basin consists of a major portion of New Hampshire, over half of the state, and a much smaller part located in eastern Massachusetts stretching into the outskirts of Greater Boston. Consequently the basin includes areas of quite diverse economic activity. The northern portion is quite undeveloped; the middle section including Lake Winnepesauke is primarily recreational; the southern section, commencing with Concord-Manchester, is increasingly industrial.

Table 1 presents some salient statistics for the basin. Given the wide diversity within the basin, these statistics must be further analyzed by sub-regions to yield a meaningful profile of the area.

Table 1

Salient Statistics of the Merrimack River Basin

	1960	1970	1990	2020
Population (000)	1,081	1,250	1,452	1,872
Personal Income (per capita)	2,951	5,078	8,089	12,842
Relative to U.S.	1.36	1.23	1.27	1.19
Employment* (000)	994	1,004	1,235	1,842
% in primary (agriculture)	1.6	1.2	.6	.3
% in secondary (manufacturing)	33.6	31.7	28.2	23.5
% in tertiary (services)	64.8	67.1	71.2	76.2

*Employment estimates seem to be based on totals for economic areas which go beyond basin boundaries.

Source: "Data for Monitoring Conference on 14-15 June 1971" U. S. Army Corps of Engineers

Figure 1 indicates the regional breakdown chosen for this analysis. Since economic data is available by county rather than by basin designation, most of our analysis must be confined to county data for the portions of the basin lying in New Hampshire and to data on SMSA's (Standard Metropolitan Statistical Areas) lying in the Massachusetts section. In this way we are able to account for roughly 90% of the land area and the population in New Hampshire, and about 40% of the population and area of the basin lying in Massachusetts. The actual breakdown is given in Table 2 which also presents population estimates for the areas covered. A part of Grafton county falls outside the Merrimack Basin, as do very small portions of Belknap and Merrimack counties.

Table 2

Economic Indicators for Subregions, 1960

Subregions	Population Density per sq. mile	Employment Mfg./Total	Population (thousands)
New Hampshire	67	39.7	606.9
Grafton	28	26.3	48.9
Belknap	72	37.7	28.9
Merrimack	73	31.5	67.8
Hillborough	199	43.9	178.2
Massachusetts			
Fitchburg-Leominster	540	50.7	90.2
Lowell	1,081	42.1	164.2
Lawrence-Haverhill	957	47.7	199.1

Source: County and City Data Book, 1967.

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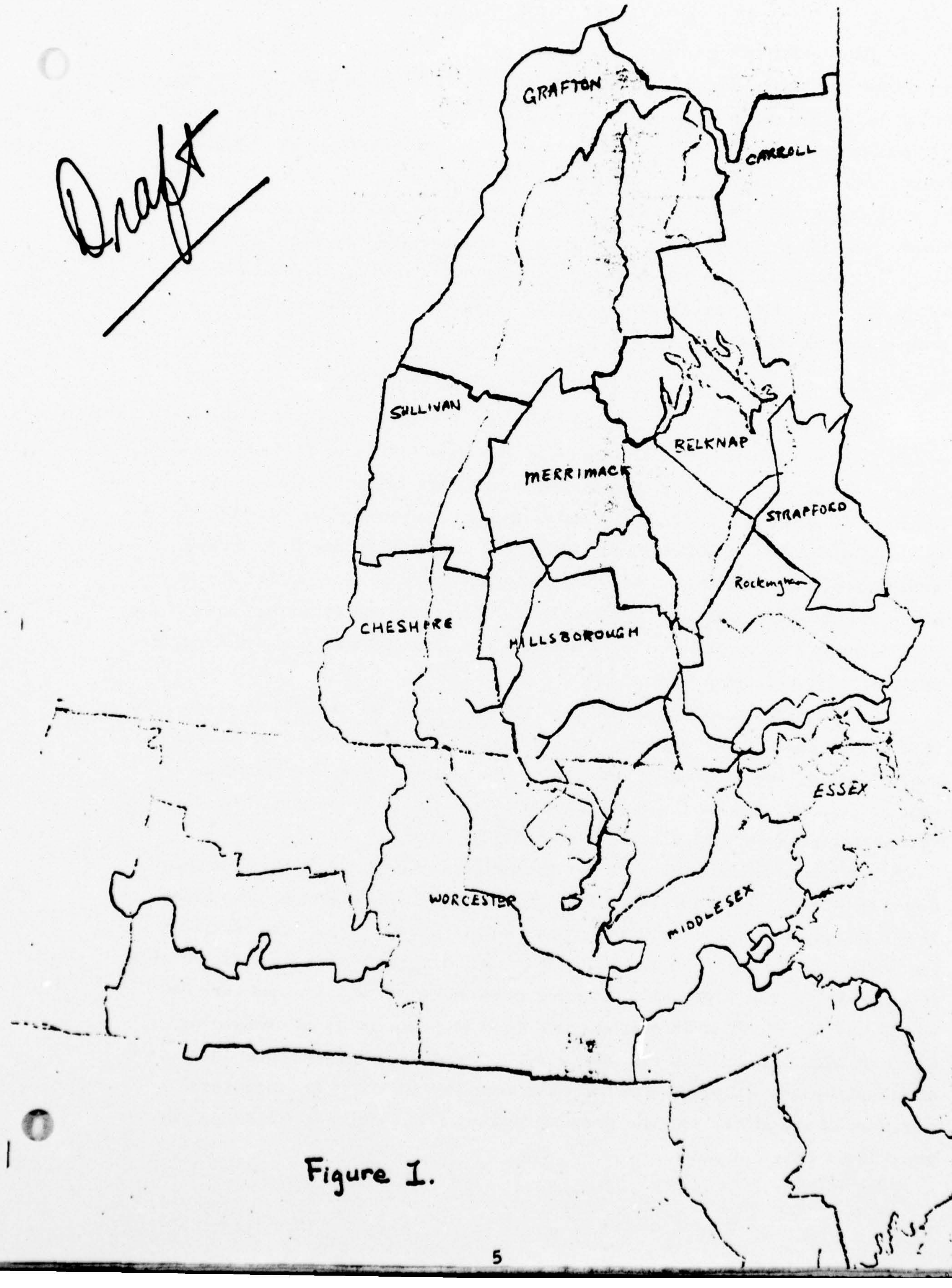

Figure I.

The economic composition of the counties changes gradually as we move southward from Grafton county, as indicated in Table 2. Population becomes more dense, and the ratio of manufacturing employment to total employment rises. A number of other indices indicate the same trend toward urbanization in the southern reaches of the basin. These will be treated in the discussion of the New Hampshire agricultural sector below. A reasonably detailed analysis of agriculture is included here since several solutions under study include land disposal of waste water, and we must make projections as to the usefulness of wastewater for irrigation and fertilizer purposes.

2.2 Agriculture in the New Hampshire Sub-regions

New Hampshire agriculture has been declining steadily in postwar years. From 1950 to 1964, the number of farms fell from 12,500 to 3,650, though a good part of this decline represented the consolidation of farm lands into larger and more efficient holdings. Nevertheless, in 1964 the average size of farm amounted to about 200 acres (half the U.S. average) with about half of all farms with less than 100 acre plots. Unlike farms in other areas of the country, much farm land in the area includes forests as well as open fields. Harvested area or area used for pasture accounts for perhaps 30% of farm holdings.

Agricultural output in New Hampshire also fell absolutely from 1950 to 1964, by about 15%. Acreage used fell accordingly. The decline has, moreover, affected virtually all branches of agriculture, including livestock, hay, vegetable, fruit, dairy and forest products output. Some salient farming statistics are included in Table 3.

While the exact reasons for the decline are not easy to pinpoint, several factors bear mention. Perhaps the most important among these is the geography of the New Hampshire area. About 85% of the land in the state is wild forest land, difficult to reclaim, and quite often unsuitable for cropping. Much of the remainder consists of rocky, uneven terrain which has not stood up to mechanization as have the soils of competing agricultural states. The climate itself is relatively unfavorable; there is about one month difference in frost between the southern and northern portions of the state, and the growing season from Belknap county northward lasts only 120 days.

The second major reason for the decline of agriculture is the slow encroachment of industrialization spreading northward from the Boston Metropolitan complex. This effect acts in several different ways. First, is the direct effect of industrial land demand. Second, the potential for employment in industry has created a serious shortage in farm labor. Third, recreational demand for land with the southern cities as the chief source has exerted a powerful upward pressure on land values. Table 4 indicates the average value of land and buildings per acre. Unfortunately, it is impossible to separate out land values, but the trends are quite clear.

Table 3

Salient Statistics of Agriculture in the New Hampshire Subregion

	Grafton	Belknap	Merrimack	Hillsborough
No. Farms, 1964	699	266	611	617
1969	990	359	903	1,000
Land in Farm (1000 acres)				
1964	183.1	49.7	115.4	100.0
1959	226.4	62.7	157.1	144.9
Land Use (100 acres) 1964				
Cropland, harvested	29.9	9.0	19.4	20.5
Cropland, pasture	12.1	2.0	8.6	7.2
Woodland, pasture	31.7	6.3	13.0	5.0
Woodland, not pastured	95.4	25.6	61.5	53.1

Source: Census of Agriculture

Table 4

Average Value of Land and Buildings Per Farm Acreage, 1964

New Hampshire	$ 132.12
Grafton County	77.87
Belknap	136.23
Merrimack	122.93
Hillsborough	200.33

Source: Census of Agriculture

A third reason for the decline of New Hampshire farming can be found in the changes experienced by the agriculture industry in general. Transportation networks and technologies connecting the population centers with the producing areas have improved considerably, and the comparative advantage of the Northeast as a supplier has declined accordingly. The advances referred to here also include shifts in the vertical structure of the agriculture industry; many more products reach the consumer in processed (frozen, canned, etc.) form than, say in 1950.

A fourth reason can be traced to the land conditions of the area. The nature of the topography has segmented farmlands to the extent that average holdings are nearly one-half of U.S. averages. This factor, reinforced by the age of the agriculture industry in the area, has resulted in small-scale, and necessarily less efficient farming at levels below those required for achieving competitive economies of scale.

Table 5 presents the present breakdown of agricultural production in the counties included in the present study.

Table 5

Agricultural Production in the New Hampshire Subareas, 1964

	Grafton	Belknap	Merrimack	Hillsborough
Crops ($000)	619.1	344.8	887.6	2,103.9
Vegetables	21.8	16.5	95.2	552.6
Fruits & Nuts	85.9	199.7	232.9	976.2
Forest Products	346.7	93.2	344.0	403.4
Field Crops, other	164.7	35.4	215.5	171.7
Livestock ($000)	5,001.5	1,490.0	4,966.2	8,081.5
Poultry	577.4	578.9	1,963.8	4,871.7
Dairy	3,793.0	831.2	2,500.4	2,723.7
Nes.	630.9	79.9	502.1	486.2

Source: Census of Agriculture

As is quite evident from the table, poultry farms and dairy farms account for most of the agricultural production in the counties studied. Fruits and nuts show as a poor third, with vegetables and forest products in last place with roughly equal amounts. Poultry products and dairy products appear aprominently primarily because of the closeness of the city markets; in addition, poultry farming represents an intensive form of agriculture well-suited to the southern reaches of the basin.

2.3 Baseline Projections for Agriculture

As the foregoing indicates, the agriculture industry in New Hampshire faces rather severe obstacles to development. The factors which have accounted for the shrinkage during the past decade are likely to intensify. Encroaching urbanization and industrialization is likely to further increase land values (and taxes), and to offer employment alternatives to potential farm labor. In addition, the southern and central portions of the region have experienced heavy land demand for recreational purposes. In Belknap county, for example, nearly 40% of structures are used seasonally by owners from the southern cities.

On the other hand, the competition fostered by the shrinking industry has served to solidify the surviving segments. Accordingly, farm size and capital/farm have grown steadily, allowing for increasing utilization of modern labor-saving equipment. This development, some experts feel, will tend to slow the level of decline of the industry, particularly in dairy production.

According to the Cooperative Extension Service at the University of New Hampshire, the number of cows is likely to decline from about 36,000 in 1970 to about 30,000 in 1980. The consolidation of farms within the industry is likely to continue during the next decade, with herds continually increasing in size. The average size by 1980 is expected to increase from 46 to 83.

We have been unable to locate similarly concise forecasts for other branches of the agriculture industry in New Hampshire. On the basis of qualitative information and discussions with experts, we estimate that poultry production is likely to maintain at least 1963 levels throughout the 1970-1980 decade, while fruits and vegetable production should decrease by

about 25% during the period. These estimates are extremely rough, and further refinements are necessary before they are used in final form.

One economic area in the basin showing significant recent increases is the production of red meats; beef and pork. This trend, caused partly by increases in demand during the late 60's, has not yet stood the test of longer periods of competition. Possible increases in this area may well compensate the livestock losses that are expected to take place in dairy production.

2.4 Potential Impacts on Agriculture

The possible impacts of land disposal scheme are here examined in some detail for the agricultural areas of New Hampshire. It must be understood that we can at best make only tentative estimates of potential impacts. Further study is essential if land disposal schemes remain among feasible alternatives for water management in the basin.

About 80,000 acres of land are slated for various forms of land disposal, almost exclusively in Merrimack and Hillsborough counties. While the land areas of Grafton county could possibly offer more suitable land disposal opportunities, most waste water releases in the basin are well south of Grafton county, and it is unlikely that the slightly more advantageous location would justify the cost of pumping that far north.

Much of the area deemed suitable for land disposal is located along the Concord-Nashua stretch of the Merrimack River. This area is in fact one of the more agricultural portions of the state, and thus provides some opportunity for productive use of the land irrigation scheme. In the next few pages, we outline very general impacts of land disposal in these two counties; the analysis is roughly applicable to Solutions 4-7, with irrigation effects in Maine and Massachusetts ignored at this time. An attempt will be made later to try to isolate differences among the various alternatives under study.

The Concord-Nashua stretch is reasonably interesting from the viewpoint that most of irrigation which takes place already in New Hampshire appears to be practiced in this area. The source of the water is the Merrimack, polluted as it is. Some experts we interviewed seemed to

feel that certain products grown in the area in fact show effects of the pollution; blueberries and other fruit eaten raw allegedly show dangerously high coliform counts.

In Sections 2.4.1-2.4.5, the possible impacts of land disposal and the availability of clean river water on the several agricultural activities of the region are considered.

2.4.1 Fruits and vegetables eaten raw

Land disposal of waste water is considered by some to be infeasible for fruits and vegetables eaten raw since effluent coliform levels are likely to be above health standards. Consequently, in order to be used as land water disposal sites, land presently used for certain fruits and vegetables would have to be converted to crops that are at least cooked before human consumption. Much of the Concord-Nashua stretch does in fact specialize in products eaten raw, though the farms used for these purposes are usually too small to make irrigation profitable. Thus, not only conversion to a different crop, but also cooperative irrigation agreements would be needed to make use of this land for waste water irrigation purposes.

A good deal of the present irrigation is practiced by taking untreated water from the Merrimack River. Since some experts feel that the crops already exhibit dangerous coliform level contamination, it can be assumed that eventually, unless the river is cleaned, the irrigation of these crops from the Merrimack will be prohibited. Under these circumstances, production would virtually stop. Thus, the clean river itself, regardless of the method of treatment used, would represent a considerable advantage to growers, an advantage which is in fact tantamount to survival. Needless to say, the losses sustained by a halt in production would not amount to the entire value of the production since it is likely that farmers who intend to stay in the business would change crops. But in any case, the burden of switching might be severe enough (not only from a financial viewpoint, but also from the viewpoint of human capital: farmer knowhow, experience with growing and distribution, etc.) to cause significant frictional losses as a net result.

2.4.2 Other vegetables

Other vegetables growing in the area, like squash, etc.) could potentially benefit from the use of waste water as an irrigant as well as a fertilizer. In later sections, some quantitative guesses are made as to the magnitude of this effect. However, an important question arises as to the practicability of using waste water as an irrigant if the river is in fact clean, and could be used directly. For the most part, irrigation areas would have to be located near the river anyway in order to minimize pumping costs and to take advantage of the sandy soils surrounding the riverbed. (This is not the case with some irrigation activity about ten miles west of the river in order to use waste water from the Fitchburgh Leominster area.) Since the wastewater disposal areas are located near the river, it is likely that farmers would prefer the control and familiarity of conventional irrigation and fertilizer techniques unless the alternative of wastewater land disposal were made terribly attractive by financial incentives. The nature of these incentives amounts to subsidies by urban areas to farmers permitting disposal. Otherwise the value of the waste-water as fertilizer would alone have to make its use, and the accompanying inconvenience, worthwhile. This value may in fact be quite low, as estimated in Section 2.5.

2.4.3 Dairy production

Some physical problems exist in using waste water as an irrigant for fields used often as pasture. First, the question of the effect of possibly high coliform concentrations as pasture land has not been adequately investigated with regard to possible effects on livestock. Second, only partial use of the fields would be possible in that the animals could not be permitted onto irrigated acreage until at least one day after irrigation has been stopped, since they may produce depressions in the pasture which could act as collectors of wastewater. If three days of irrigation are applied, the land would be useful for three-sevenths of the time. However, additional production of grass (possibly as much as 100%) could justify some system of land rotation for pasture use. This system should be costed out, though it is likely that the additional management expense

and the fact that,no matter how we look at it,only some fraction of pasture acreage could be irrigated at any given time, may make the system impractical from a financial viewpoint.

2.4.4 Forest production

There seem to be no outstanding problems in using wastewater as an irrigant for forest land. One expert has suggested that with careful management alone good profits could be achieved in the New England forestry industry. From evidence collected by Pennsylvania State University in the course of forest wastewater irrigation experiments, significant improvements can be obtained from well managed forest irrigation. Table 6 shows increases in seedling growth on the irrigated land versus control land. The differences are quite significant, and a rough guess would put possible forest product output increases at 50%. Needless to say, tree growth alone does not generate increases in forest output.

Table 6

Total Height Growth of Surviving Seedlings from 1965 to 1969

Species	Total Height (ft.)	
	Irrigated	Control
European larch	6.8	*
Japanese larch	6.4	*
White pine	5.1	2.1
Red Pine	3.0	1.6
White spruce	2.9	2.2
Pitch pine	2.9	1.0
Austrian pine	2.7	1.9
Norway spruce	2.4	1.4

*No trees of these species survived on the control plots.

Source: Pennsylvania State Study.

Management is of primary concern, and changes in land values may not allow forest production in the two counties in question. If, however, some sort of green belt scheme is guaranteed by the local governments for quite different considerations (air quality, natural beauty, etc.) well-run

selective cutting operations could achieve economic significance in the area. One problem which should be studied in greater detail is the type of forest production generated by such programs. Some experts feel that foliage growth may overshadow trunk growth under heavy irrigation-fertilization schemes and the net effect would not be advantageous from the viewpoint of commercial lumber production.

2.4.5 Other agricultural production

Hay and similar crops are known to respond well to the wastewater application tried, for example in Texas. Production might increase 50-100%. Some experts feel that the primary difficulty in the New Hampshire area is not so much the productivity of the land but rather management problems that are attributable to small-scale farming operations in the area.

Poultry farming is not likely to be affected unusually either by the presence of clean Merrimack water, or by land disposal schemes.

2.5 Benefit Approximations for Agriculture

2.5.1 Fertilizer content of sewage effluent

Two basic sources have made independent estimates of secondary treated sewage as a substitute for commercial fertilizers.* Their results are tabulated below, and since there is fairly close agreements between the sources, it was assumed that similar concentrations would result from the application of one inch per week of effluent in the Merrimack Basin as well.

Table 7

Fertilizer Content of Sewage Effluent

ppm / Experiment	N	P	K**	Calcium
Frogtown, La.	20	7	40	100
Frazier Creek, La.	16	10	35	100
Penn State, Pa.	26	9	19	26

*"A Technical and Economic Feasibility Study of the Use of Municipal Sewage Effluent for Irrigation," Louisiana Polytechnic Institute. Sopper "Effects of Trees and Forests in Neutralizing Waste," Pennsylvania State University.

**N = Nitrogen, P = Phosphorus, K = Potassium

The Pennsylvania State source estimates that year-round application is therefore equivalent to 1,500 lb. of commercial 12-9-10 fertilizer. Since the price of the closest commercially-available fertilizer in the area (10-10-10) is a one inch application for the summer months only, would have a value of approximately $25 per acre. Accordingly, a three inch application can be valued at roughly $75 per acre. (The Louisiana source estimates considerably lower fertilizer benefits per acre, $14.50, but does not give any estimate of the rates of application used.) In light of the conflicting information, our estimate of fertilizer content was revised downwards to $40 per acre for three-inch irrigation for about thirty weeks per year.

2.5.2 Irrigation value of sewage effluent

The Louisiana source cited above made some comparison of effluent application as an irrigant versus other water methods. In the case they studied, alternative sources of water supply were a nearby lake and deep wells. Irrigation costs per acre (annual fixed and operating costs) for the three alternatives amounted to:

Table 8

Annual Irrigation Costs by Method

Source	Cost Per Acre
Lake	$ 54.82
Sewage	58.73
Deep Well	105.78

Source: Louisiana Polytechnic Institute studies.

Thus effluent irrigation costs (excluding pumping to the property) are about the same as irrigation costs from nearby water sources, about $50 per acre. The Louisiana researchers found no major problems in using conventional equipment for irrigation with sewage effluent provided proper size sprinkler nozzles are selected.

2.5.3 Maximum possible benefits

The extreme case here is the situation where we value the benefits resulting from sewage effluent land disposal at the cost it would take to provide equivalent fertilizer and irrigation. This assumption of course is quite unrealistic, and might at best be used as a guide in areas where all of the irrigated land area is used in commercial farming, and where irrigation must necessarily be practiced as a result of land and climate conditions. This is clearly not the case in the Merrimack Basin, and more realistic estimates will be derived in the following section.

The maximum benefit is the amount of land to be irrigated, times the value of irrigation as estimated by the cost of irrigation from an easily accessible alternative water source. In the Merrimack Basin some 80,000 acres are scheduled for land disposal under the alternative 4-7. Multiplying by $50 per acre, the value of the land disposal scheme as an irrigation method under the maximum benefit assumption is about $4 million.

The value of the fertilizer at $40 per acre at three inch application times 60,000 acres scheduled at this rate of application, plus $15 per acre at one inch application (overland flow) times 20,000 acres scheduled at this rate would equal about $2.7 million.

Total maximum benefits from the land disposal aspects of schemes 4-7 would amount to about $6.7 million annually, provided that both fertilizer and irrigation were used optimally to replace equivalent amounts of alternative fertilizer and irrigant. These benefits are estimates for the New Hampshire irrigation areas, and do not include possible irrigation in Maine.

2.5.4 Most likely benefits to agriculture

The value of all sales of agriculture in the Merrimack and Hillsborough counties amounted to only $19 million in 1963. Consequently, the previous estimate for fertilizer and irrigation use cannot be seen as a realistic estimate of input cost savings. In fact, total application of fertilizer in these two counties amounted to about $350,000 applied to some 23,000 acres at an average rate of about $15 per acre. Thus, considerably less fertilizer (the average value per ton somewhat exceeds our $40 estimate) was applied per acre than would be via the

the use of land disposal, and the acreage to which fertilizer was applied amounted to somewhat over half of the acreage to be irrigated with sewage effluent.

Table 9

Fertilizer Use and Irrigation in 4 Counties, 1964

	Grafton	Belknap	Hillsborough	Merrimack
Area Irrigated (acres)	16	34	1,203	652
Cropland	16	32	1,176	521
Pasture	-	2	20	121
Other	-	-	7	10
Fertilized Area (acres)	12,048	3,382	13,509	10,516
Tons	2,610	615	3,352	2,223
Value (commercial farms only) ($000)	195.1	43.7	208.7	146.4

Source: Census of Agriculture

The picture was even more stark with respect to irrigation practices existing in the area. In the two most heavily irrigated counties only about 1855 acres were irrigated, as opposed to the projected 80,000 acres. Consequently, the use value of the land disposal alternative must be revised downward in face of the available evidence.

First, we shall attempt to separate out land use categories in the land disposal areas. Rough estimates indicate that the 20,000 overland flow acreage consists entirely of woodland, while some 60% of the remaining 60,000 acres scheduled for spray irrigation is also woodland. Assuming that clearing operations will not be undertaken to claim present woodland as cropland for the sake of better utilization of the effluent, only about 24,000 acres remain for actual cropland or pasture use.

The effect of irrigation on woodland is estimated here not by the fertilizer value of the effluent, but rather by some rough estimates of production increments likely to be brought about by forest irrigation. We somewhat optimistically assume that 50% productivity increases can be

expected from effluent use. Farm and forest products amounted to about $750,000 for the two counties from about 115,000 acres of farmland in forests. This indicates an average production of about $7 per acre of forest, showing quite clearly the lack of efficient cutting and management of woodland in the area. A 50% gain in productivity would set the additional forest product increment due to land disposal at about $3.50 per woodland acre. Multiplied by woodland acreage to be used for land disposal purposes, the added product from forests would amount to about $200,000 annually.

Provided the land use estimates are correct, about 24,000 acres of cropland harvested or pastured would be irrigated with the wastewater. In the two counties, there are about 40,000 acres of harvested cropland and about 34,000 acres of pasture land. Of these 74,000 acres about 24,000 acres are fertilized, and about 1,850 irrigated. Assuming that all of the present irrigation systems can be switched to utilize wastewater, savings of $50 per acre would result for the 1850 acres amounting to somewhat under $100,000.

Assuming that fertilizer on pasture land has no value, and the ratio of harvested land versus pasture land is about the same for the land disposal area as for the two counties' average, some 13,000 presently fertilized acres could obtain the benefits of wastewater fertilization. If we further assume that farmers simply cease to purchase fertilizer, at the existing average rate of $15 per acre, savings here would amount to about $200,000.

Cost savings for fertilizer and irrigation total about $300,000. If we add to this one half of the production increment generated in forest products as a very rough measure of net benefit after allowance is made for increases in costs necessary to reach higher levels of output, we come to a final "most likely benefit" estimate of about $400,000 annually. This represents strictly savings based on present economic practices in the area. Further savings may materialize if the technologies of the producers adapt to the land disposal opportunities efficiently, perhaps doubling the size of the total benefits accruing to the two counties.

Thus, annual benefits of about $500,000 - $1,000,000 may be expected to result from the land disposal schemes 4-7 from the viewpoint

of the agricultural industry. These benefits assume that the farmer spends no labor or maintenance work in connection with the land disposal system, that is, the water management authorities take full responsibility for operation and costs. While these benefits are sizeable from the standpoint of the industry (amount to about 5% of agricultural sales) they are probably dwarfed by the cost of installation of distribution and irrigation systems. And most importantly, these computations are based on the critical assumption that the fertilizer and irrigation effects of the wastewater system fit ideally the growing requirements of the crops and forests sprayed. A good deal of research must be done before we can be assured of even the approximate validity of this assumption. If it is not valid, the system could generate additional costs instead of savings. The margins are, as argued, not very wide for the River Basin under study.

A comparison of the "maximum possible" and "most likely" benefits underlines a rather important point. The fact that a land disposal scheme may not pay in the Merrimack River Basin does not by any means indicate that the concept itself is faulty. In an arid area with good, deep soil adaptable to large scale mechanized farming, the concept may work quite well. Even pasture land is quite often irrigated in arid portions of the United States; large rotary irrigators have been devised to spray circular pieces of land one-half mile in diameter, with the cattle following the sweeping arm of sprinklers. If most of the estimated $6.7 million of annual benefits could be brought to bear directly on agricultural production, the wastewater system would be quite close to paying its own way.

What the effect of these benefits will be in light of the predicted decline of the agriculture industry is unknown. A possibility is that benefiting farms will stay alive, and in fact become more profitable partly as a result of the planning and thought required to make the irrigation system work.

But consideration ought to be given to what action will be necessary if the irrigated areas are abandoned by private enterprise. Scenarios must be examined for abandoned areas including possible costs to be borne by the municipalities to maintain the areas in sufficiently good condition to assure system operation.

3.0 MANUFACTURING AND POTENTIAL IMPACTS

3.1 Manufacturing in the Merrimack River Basin

Manufacturing employment has risen steadily in both the New Hampshire and Massachusetts portions of the basin. Increases were made in the New Hampshire segment by food products, chemicals, plastics, etc., by primary metals, and by industries related to the use of lumber, paper and wood products. A general decline has hit the textile and leather industries over the entire basin, with the Lowell area feeling the effects most strongly. The Massachusetts portions have seen a particularly rapid increase in the electronics, chemical, and metal products associated with the famous Route 128 complex in southern portions of the basin. The electronics activities have experienced severe cutbacks in the past year, and their future development is less optimistic today than forecasts in the mid-60's indicated. The machinery production throughout the region can expect a relatively optimistic future. Establishments with over twenty employees are listed in Table 10. Office of Business Economics projections for two areas, (a) the Manchester area which includes all of the New Hampshire portions of the basin and some other counties in New Hampshire, and (b) for the Boston Water Region area which includes Eastern Massachusetts and Rhode Island are also presented as a guideline for the industrial outlook of the region (Table 11 and 12). The precise composition of industry in the New Hampshire segment is included as an appendix to this report. Time has not permitted us to make detailed projections using this data, but its existence should make future research considerably simpler.

As the OBE data indicate, future increases are likely in manufactures in the river basin. The particular composition of the increases is not known; OBE in particular projected future employment only for a few sectors which are rather poorly represented in the region under study. But it is likely that the lumber-related industries will continue to develop, though forest production may be quite independent to the extent that import potential from Maine and Canada is signficant. In addition, the rubber and related plastic products are likely to show significant development.

Table 10. Manufacturing Establishments with Over 20 Employees, 1963

Manufactures, 1963		Fitchburg-Leominster SMSA	Lawrence-Haverhill SMSA	Lowell SMSA	Belknap	Grafton	Hillsborough	Merrimack
All Employees, Ann. Aug	No.	17485	42020	21120	3635	4581	34679	7678
Payroll, Entire Yr	$1,000	92082	214286	102594	17149	19421	159166	35339
Production Workers, Ann. Aug	No.	13797	30629	16630	2922	3963	27516	6532
Man-Hours	1,000	28535	58626	32235	6312	8348	53433	13003
Wages, Entire Yr	$1,000	64882	132854	69367	12879	15083	110221	26279
Value Added	$1,000	167851	365306	168649	27750	28545	258455	64082
Capital Expend., new	$1,000	14476	16276	5871	1049	[illegible]	10386	4385
All Employees, Ann. Aug	No.	16976	36378	19104	3698	[illegible]	32533	5923
Value Added	$1,000	126072	268186	115353	25178	24395	189738	35773
Total Establishments		289	476	298	85	117	449	169
Total w/x ≥ 20 Employees		123	193	136	27	34	201	64
w/20 ≤ x ≤ 99		NA	NA	NA	17	22	120	42
w/100 ≤ x		NA	NA	NA	10	12	82	21
Food and Tobacco Prod.		8	17	12	2	--	20	4
Textile, Apparel & Leather Prod.		17	95	63	10	11	65	17
Paper & Printing		14	16	15	2	8	13	12
Chem, Oil, Rubber & Plastics Prod.		34	16	11	--	1	11	1
Lumber, Wood Prod & Furniture		9	10	4	3	5	27	10
Stone, Clay & Glass Prod.		--	2	4	1	2	8	2
Prim & Intermed Metal Prod.		8	9	9	2	2	17	6
Elec & Nonelec Machinery		15	20	12	4	4	30	11
Transp & Ordnance (incl. Missiles)		2	--	1	--	--	--	1
Instruments & Misc. Prod.		14	3	2	3	1	7	--

Source: U.S. Bureau of Census, County and City Data Book, 1967 (A Statistical Abstract Supplement), U.S. Government Printing Office, Washington, D.C., 1967

Table 11. Population, Personal Income and Earnings, Projected for Selected Years, 1970-2020

Manchester, N. H., Water Resources Planning Area
(Belknap, Carroll, Hillsborough, Merrimack, Rockingham, and Strafford Counties.)

	1970	1980	1990	2000	2010	2020
Population	511,100	581,300	678,300	774,000	891,600	1,020,600
Total Personal Income (000-$58)*	1,567,831	2,390,135	3,625,968	5,542,560	8,440,926	12,666,187
Per Capita Income ($58)**	3,067	4,111	5,346	7,161	9,467	12,411
Per Capita Relative (US=1.00)	1.01	1.00	1.00	1.00	1.00	1.00
Total Earnings (000-$58)*	1,217,141	1,830,145	2,726,590	4,103,269	6,164,722	9,144,572
Per Worker Earnings ($58)**	5,824	7,544	9,877	12,945	17,153	22,572
Per Worker Relative (US=1.00)	.92	.93	.95	.95	.96	.97

* Incl. Armed Forces Pay

Employment by Selected Industries, 1970-2020

	1970	1980	1990	2000	2010	2020
Population	511,100	581,300	678,300	774,000	891,600	1,020,600
Total Employment	209,000	242,600	276,100	317,000	359,400	405,100
Participation Rate (Empl/Pop)	.41	.42	.41	.41	.40	.40
Agriculture Forestry + Fisheries	3,700	2,900	2,400	2,000	1,700	1,400
Mining	D	D	D	D	D	D
Manufacturing	78,100	83,900	90,100	96,400	102,700	109,600
Food + Kindred Products	2,600	2,600	2,500	2,600	2,600	2,700
Textile Mill Products	7,800	6,800	6,100	5,400	4,800	4,300
Chemicals + Allied Products	500	700	800	1,000	1,200	1,400
Paper + Allied Products	2,200	2,200	2,100	2,200	2,200	2,100
Petroleum Refining	D	D	D	D	D	D
Primary Metals	1,400	1,500	1,700	1,800	2,000	2,100
Armed Forces	5,500	5,300	5,300	5,300	5,300	5,300
Other	121,600	150,400	178,300	213,200	249,600	288,800

** Computed from unrounded data.
D Too small to be projected but included in higher level totals.

Source: Office of Business Economics Projection

Table 12. Population, Personal Income, Earnings and Employment
Historical and Projected for Selected Years

North Atlantic Hydrologic Sub-Area
[Including Belknap, Merrimack and Hillsborough Counties (New Hampshire), and
Worcester and Middlesex Counties (Massachusetts)]

	1959	1960	1980	2000	2020
Population	2,080,579	2,095,731	2,570,800	3,212,800	3,976,000
Total Personal Income (000-$58)*	4,994,795		11,611,100	24,854,900	52,904,800
Per Capita Income ($58)**	2,401		4,517	7,736	13,306
Per Capita Relative (US=1.00)	1,125		1,098	1,080	1,072
Total Earnings (000-$58)*	4,039,794		9,169,400	19,286,400	40,544,300
Per Worker Earnings ($58)**	4,876		8,641	14,594	25,063
Per Worker Relative (US=1.00)	1,045		1,069	1,072	1,073
Population	2,080,579	2,095,731	2,570,800	3,212,800	3,976,000
Total Employment	828,576	835,039	1,061,100	1,321,500	1,617,700
Participation Rate (Empl/Pop)	.398	.398	.413	.411	.407
Employment by Selected Industries					
Agriculture Forestry + Fisheries		10,822	7,800	6,000	4,500
Mining		618	300	200	200
Manufacturing		321,326	336,400	365,000	396,600
Food + Kindred Products		21,138	16,700	14,700	13,800
Textile Mill Products		27,021	15,400	10,900	8,000
Chemicals + Allied Products		7,002	9,000	11,000	13,100
Paper + Allied Products		14,451	16,400	18,500	20,300
Petroleum Refining		1,281	500	300	100
Primary Metals		12,420	15,100	17,100	18,900
Armed Forces		14,631	11,500	11,500	11,500
Other		484,684	702,400	934,500	1,199,100

D Too small to be projected but included in higher level totals
* Including Armed Forces pay

Source: Office of Business Economics Projection

The outlook for electronics is not clear at the present time, depending on the course of weapons production during the next decade.

The labor markets of the area are quite good from a number of different viewpoints. Technical personnel is available from the Greater Boston complex of universities. Unskilled labor is also in abundance in the Route 495 belt stretching across the Massachusetts SMSA's under study. If a shortage exists, it is likely to be in the area of skilled machine operators.

Industries requiring technical personnel would find the basin area quite attractive. Living conditions and ample recreation opportunities make the area quite attractive, and the urban developments are still sufficiently separated to provide relatively inexpensive housing for employees. The proximity of Boston is also a possible advantage. Transportation facilities are good in terms of road networks, though rail transportation is inadequate for long distance shipping of any significance.

3.2 Likely Impacts on Manufacturing in the River Basin

Clean water is essential to several industries. Coupled with the strengths of the area outlined above, it is likely that clean water will attract new industry into the area. There is also on indirect effect: improved water quality may be a significant factor from the viewpoint of attracting qualified personnel.

It is impossible to make any concrete projections of the kinds of industries likely to respond to the improvements in water quality. We enclose, without any direct comment, a list of industries and their water requirements, as expressed in terms of three ratios: (1) water intake per dollar value added; (2) water used directly for process per dollar value added; and (3) percentage of water treated before use. The last indicator may show correlation with the degree of water quality needed for purposes of a specific industry. The extent of the correlation however would have to be explored industry-by-industry in order to ascertain what kind of treatment is actually applied, and whether or not the water management schemes are likely to make a difference in cost to the individual industries.

Table 13. General Industrial Wat Usage Data for U.S., 1963

SIC	Industrial Class	Total Gallons Intake/ $ Value Added	Gallons Process Use/ $ Value Added	Percentage of Intake Treated Prior to Use
--	All Industries	.14798	.03100	.20876
20	Food & Kindred Products	.07545	.02621	.14868
21	Tobacco Manufacturers	.00267	.00089	.33333
22	Textile Mill Products	.00587	.04002	.60811
24	Lumber & Wood Products	.26307	.09756	.09272
25	Furniture & Fixtures	.00977	.00326	.33333
26	Paper & Allied Products	.53709	.34855	.47658
28	Chemicals & Allied Products	.30882	.04480	.17978
29	Petroleum & Coal Products	.45600	.02870	.12017
30	Rubber & Plastics Products, Nec.	.06112	.00712	.14724
31	Leather & Leather Products	.07018	.06140	.12500
32	Stone, Clay & Glass Products	.07302	.02767	.20080
33	Primary Metal Industries	.39802	.08659	.15269
34	Fabricated Metal Products	.017785	.00936	.01778
35	Machinery, Except Electrical	.02393	.00351	.08280
36	Electrical Machinery	.01090	.00291	.14286
37	Transportation Equipment	.01315	.00309	.12551
38	Instruments & Related Products	.01374	.00568	.41379
39	Miscellaneous Manufacturing	.02457	.00945	.15385

We do not at this point wish to pick any industries from the above list as potential candidates for location in the basin area. The question of industrial location is perhaps the most complicated problem of regional economics, and even with several man-years of study only highly tentative answers can be given. One promising approach focuses on the establishment of interrelated industrial complexes which make efficient use of certain valuable resources of a given area. The wood-related industries could show potential in this area, and probably justify a thorough study. In this type of analysis existing industrial linkages are measured, and potential industrial linkages are evaluated from the viewpoint of long-term profitability. Thus, the analysis of the forestry -- lumber -- paper -- container chain may uncover unusually strong opportunities which have not yet been exploited fully by private industry. Another related industrial area which has in fact shown some signs of development in the Lowell area is the prefabricated housing industry.

As an example of industrial complex analysis, we cite here from the study by Muskegon County, Michigan, which sought to fit its land disposal scheme into a profitable, large scale industrial complex. The idea there was to use land irrigation for growing corn in previously unproductive areas. The corn was then viewed as an input into a large scale corn refinery. The refinery in turn would have supplied inputs to paper manufacturing, certain chemical industries, as well as food processing, livestock feed and human consumption. As an indication of the wide diversity of furture linkages possible, we include here an appendix from the Muskegon report which shows the number of different products available from corn refining.

No similar attempt is undertaken in this report. A project of this nature usually involves many man-years of research effort. Nevertheless, the true magnitude of possible manufacturing impact cannot be assessed in any realistic form without a comprehensive study of the opportunities arising from the new water management system.

3.3 Industrial Savings from Clean River Water

It is unlikely that substantial direct savings would result from clean water in the Merrimack Basin. The problem is quite fundamental: the standards for adequacy of water are quite different for human and industrial uses. Bacterial contamination is rather unimportant from the viewpoint of industry, while certain chemical properties acceptable for human use such as dissolved solids and hardness have undesirable affects on equipment such as boilers, or even in some cases cooling units.

Industrial users usually perform appropriate chemical treatment of intake water to ready it for their special purposes. It is unlikely that they could dispense with this treatment even if the water were clean enough for human consumption. Boston Edison, for example, spends as much as 40¢ per 1,000 gallons for treatment on water taken from the Boston municipal supply. Most of this treatment requirement would remain even after the proposed purification programs of alternatives 1-7.

The removal of dissolved solids from the water -- which most likely would remain in the case of water taken from the Merrimack even after the purification -- is relatively costless in view of the substantial expense required to treat water for purposes of chemical adequacy. Thus, the filtering of solids is usually easily incorporated into the design for chemical pretreatment facilities without additional cost.

It is not possible at this time to estimate savings from wear and tear, were the water purified. Most probably, on the basis of discussions with experts, savings thus obtained would be insignificant.

In summary, the direct savings to be experienced by manufacturing are likely to be negligible. On the other hand, indirect impacts through new industrial development may be quite large, to the extent of redirecting the entire industrial orientation of certain sub-regions within the basin. These changes are much too complicated even for qualitative analysis within the present research constraints.

4.0 OTHER IMPACTS

A large number of different, and quite likely less significant impacts are dealt with in this section in a qualitative manner. We cannot, however, claim that this study exhausts the list of possible impacts. While we have made an attempt to cover as many areas as possible, we have not had the opportunity to achieve a level of familiarity with the local economies to permit full confidence.

4.1 Employment

A discussion of the likely employment effects of the alternatives must be based on four different considerations:

(a) employment changes in agriculture;

(b) employment changes in manufacturing;

(c) employment changes in services; and

(d) employment directly generated by the alternative waste-water management methods.

We have spent some time in describing agricultural and manufacturing impacts. These impacts will most likely directly affect employment in their respective areas. For example, if fertilizer savings are of enough benefit to cause expansion in the agriculture industry, employment would be drawn back into agriculture. Yet the rather important statistic that only 3% of the area population is involved in agriculture, forestry, and fisheries indicates that even large scale changes in industry cannot make significant dents in the overall employment levels of the region. By the year 2000 the agricultural employment ratio is expected to fall to about 0.7%. Thus, even if the systems double agricultural employment levels, overall employment impacts are likely to be well below 1% of the labor force.

In the case of manufacturing, significant impacts, such as the possible establishment of new industrial complexes in the area, may have significant effects on the employment levels of the region. A 10% impact on manufacturing employment would result in as much as 3-5% increase in total employment.

Service industry employment can be modeled roughly as the sum of three different determinants. The first of these is the level of exports of services from the region. The second is the multiplier effect by which employment in the primary (agricultural, etc.) and secondary (manufactures, etc.) industries induces service industry employment levels. The third is the change in the multiplier itself, observed to follow a steady upward trend for some time already, and expected to continue to increase. According to this simple model, and assuming service exports unaffected, we could estimate changes in service employment simply as a multiple of changes in the employment of primary and secondary industries. The "service multiplier" as defined here would hover around 1.5 for the 1960's, reaching about 2 in the year 2000. Accordingly, the previous employment effects estimates of 1.5 for agriculture and 3% for manufacturing would probably result in service employment increases of 5-7%. The total for the area would represent an increase of about 8-10%.

It must be emphasized strongly that we are dealing here with virtually arbitrary estimates of virtually unknown effects (i.e., impact estimates of agricultural and manufacturing employment) and the results cannot be any more concrete than ball-park ranges for the impacts resulting from our assumptions. What the 8-10% increase in employment signifies is the rough change in employment _if_ we assume that the agriculture industry nearly doubles as a consequence of the project, and manufacturing increases by 10% also as a consequence of the project. The foregoing simply shows potential impacts given highly optimistic assumptions. One important feature of the exercise indicates the relatively small impact on the agriculture industry. The Merrimack River Basin is decidedly an industrial rather than agricultural area.

Direct employment effects are likely to be quite small, but at least predictable. A service multiplier of about 1.5 to 2 can be applied to estimate the overall employment effects of direct hirings by the water management system when that data becomes available.

4.2 <u>Government Finances and System Financing</u>

There is no cost data available at this time, making it impossible to estimate the burden sharing that would result from implementation of the several schemes. Since the political aspects of taxation and financing will need independent study (and may in fact be under study at this time) only some general guidelines will be offered here.

Public Law 560 offers interest-free loans for advance planning to be repaid at the start of construction of sewage related projects. Construction costs are partly borne by the Federal government; up to 75% depending on community needs, and several cities in the area are likely to qualify for maximum aid. The State of New Hampshire will pay 20% (the limit may be raised to 30% shortly) of the annual financing charges of bonds floated by municipalities for sewage disposal system financing. Massachusetts has no comparable aid. The part of construction costs not financed by the Federal government (probably an average of 50% for the region) will have to be financed by municipal bonds. These are partly guaranteed by the State in the case of New Hampshire. If the municipalities are not able to float bonds at acceptable interest rates, the Federal government is willing to provide the necessary loans at a rate of about 3-3/4%.

It is thus estimated that about 50% of the costs will have to be borne by the municipalities with roughly 4% bonds. In New Hampshire, the effective rate would fall to about 3% given the fact that the State will pay for 20% of the finance charges annually.

The present tax base of New Hampshire is summarized in Table 14 from the booklet <u>Taxes and the New Hampshire Citizen: Property Taxes</u> published by the University of New Hampshire. Flexibility measures indicate the income elasticity of the tax; flexibility of unity indicates that a 1% change in GNP results in a 1% change in the tax. A value higher than unity indicates that the tax is unusually sensitive to GNP, while a value lower than unity indicates that the tax yeild remain relatively stable regardless of business cycle conditions.

Table 14

Major State and Local Taxes Yields (1968) and Related Flexibility

Type of Tax	*Low*	*Medium*	*High*	*1968 Yield*	*% of Total*
Property Taxes	0.7	0.9	1.1	133,827,101	65.1
Income Taxes					
Individual	1.5	1.65	1.8	not applicable	
Corporate	1.1	1.2	1.3	not applicable	
Sales Taxes					
General	0.9	0.97	1.05	not applicable	
Motor Fuel	0.4	0.5	0.6	19,740,600	9.6
Alcoholic Beverage*	0.4	0.5	0.6	2,120,000	1.0
Tobacco	0.3	0.35	0.4	13,008,169	6.3
Public Utilities	0.9	0.95	1.0	3,650,000	1.8
Other**	0.9	1.0	1.1	12,912,933	6.2
Auto license and registration	0.2	0.3	0.4	11,370,182	5.5
Death and Gift	1.0	1.1	1.2	2,725,000	1.3
All other taxes†	0.6	0.65	0.7	1,525,000	0.7
Fees					
Natural Resource fees‡	0.9	1.0	1.1	3,033,388	1.4
Hospital fees (Board and Care)	1.3	1.4	1.5	1,475,000	0.7
				205,376,973	99.6

* Yield indicated is for the state tax on beer only. The state alcoholic beverage operation is not included in these figures.

** In this category are the following state taxes: rooms and meals, pari mutual sales and insurance levies.

† Included here is the head tax.

‡ Natural resource fees include state park charges and hunting and fishing license fees. State park income is for 1967.

Source: Taxes and the New Hampshire Citizen, University of New Hampshire

The state and local tax burden is relatively low in the state of New Hampshire, 8.42% of personal income in 1967, the sixth lowest in the United States, while it is relatively higher in Massachusetts, $10.41, for rank 19. New Hampshire at least does appear to be in a position to bear a slightly increased burden of taxation.

Figures for local government taxes in the subregions studied are provided in Table 15.

Further analysis will have to be undertaken when data concerning project costs is available.

Table 15

Local Government Taxes, 1962

	(Property Per Capita)	Total Taxes
Grafton	$ 139	6, 891
Belknap	155	4, 547
Merrimack	137	9, 371
Hillsborough	125	22, 490
Fitchburg-Leominster	126	10, 545
Lowell	134	21, 468
Lawrence-Haverhill	127	24, 072

Source: County and City Data Book

4.3 Recreational Impacts

Unless significant amounts of land area used for recreational purposes are claimed as land for wastewater irrigation, the overall impacts of the project, regardless of the alternative chosen, are likely to be positive. Belknap county is a major recreational area, and is likely to remain relatively unaffected, since most of the recreational activities center around Lake Winnepesauke rather than around the Merrimack River and its tributaries. Sport fishing is likely to become considerably more exciting provided water quality is significantly improved. Areas on the Merrimack River itself may reopen for boating, camping and fishing activities.

We have been unable to make an estimate of tourist generated income in the state. This analyst feels that quite likely such estimates have already been made, and could be recovered through an intensive search of the literature at state universities in the area. Since we have no baseline to use, we were unable to estimate impacts. Most of the impacts will, however, have a negative impact on agriculture. The overall effect may be to shift agriculture away from the river -- a change which

should be taken into account in planning the irrigation system and its potential expansion.

Land disposal, unless it competes directly for recreational land, is felt not to have any significant negative effects on the recreational sector. The idea of permanently maintained green belts may in fact add to the desirability of the location for recreational purposes.

4.4 Direct Construction Impacts

The construction of the system will provide a great impetus for the local economy -- for the duration of construction. While the short-term impacts are likely to be quite positive, it is absolutely necessary to insure a smooth transition back to the routine through careful planning. The U.S. space program is an excellent example of the magnitude and severity of dislocation which may follow the leveling-off stage of a high-priority program. It may be better to divert some of the income effects of the project in order to head off consequences of "disarmament" after the system is fully operative.

4.5 Land Value Impacts

Except through the indirect impacts of recreational, agricultural, industrial and residential land demand, land prices are not likely to be affected even at sites reasonably close to the waste treatment plants (if storage is located underground) and to the land irrigation areas if used. This projection is made on the basis of assurances by several experts associated with planning the system that no major problems of odor or insects are likely to develop. The matter could be quite the reverse if environmental problems do develop in the area. At first, some transition period of land value depressions could result from inaccurate expectations of what the system would mean. However, it is possible to minimize such effects by providing neighbors of the proposed sites with maximum information on the expected levels of odor, etc. perhaps by building a demonstration site ahead of the actual construction work. The fact that irrigated areas would permanently remain green may in fact have positive consequences for neighboring land values with respect to most uses.

4.6 Economic Impacts of Regional Cooperation

Possibly one of the important aspects of several of the alternatives is the fact that they require considerable regional cooperation. In time, this would necessarily lead to better exchange of information between local planning organs, and offer possibilities for more efficiently shared facilities to provide regional economic planning. If the water resources planning is coordinated with joint economic planning considerable benefits could be realized by the area from the viewpoint of coordination of economic development plans and facilities to attract industry. The study necessary to get good assessments of the impacts of a proposed plan is probably of value in itself in helping the communities of the region plan their development.

4.7 Uniqueness of Water System

The very fact that the water management system is comprehensive and unique may help the region in its search for new industry. The technologies associated with large-scale innovative treatment require hardware which might induce producers to locate directly in the basin.

4.8 Water Resource Research Opportunities

The proximity of several universities to the area planned for implementation of the water management program may provide an excellent research basis on water resources development and, if land irrigation is implemented, agricultural technology. This in itself may be of considerable benefit not only to the region but to the United States as a whole.

5.0 CONCLUSIONS AND ASSESSMENT OF ALTERNATIVES

5.1 General

The direct impact of clean water is not so much of economic benefit as it is on improvement in the quality of life in the region. This in turn may have economic repercussions as discussed in this paper. It may help in attracting a larger labor force and consequently industry. It may generate more effective economic planning and it may act as a good psychological incentive in the attraction of new industry to the region. The benefits of clean water in terms of input cost savings (that is, savings on wear and tear on equipment and on intake water treatment) have not been estimated here, partly because the necessary standard depends on the industry in question and cannot be ascertained without at least a survey of firms in the area. Qualitative information does appear to indicate, however, that the magnitude of these savings is likely to be quite small.

The impact of irrigation via the overland flow method may cause increases in the production of forest products if proper management techniques are adopted and effluent irrigation research continues to produce positive results. Whether the forestry industry will be able to take advantage of these potential opportunities is an open question; if the present trends are taken as indicative of the future, the answer may well be negative. However, some \$200,000 of additional annual output could result from the combined effects of overland flow and spray irrigation of woodlands.

The impact of cropland irrigation via effluent spray could result in substantial savings of fertilizer and alternative irrigation, valued at about \$300,000 annually, assuming 60,000 acres of spray irrigation for about thirty weeks per annum. Unfortunately, the desirability of irrigation for two of the region's major agricultural products -- dairy products and vegetables and fruits eaten raw -- is as yet unclear.

5.2 Assessment of the Alternatives

Scheme 1: Local tertiary (T) treatment plus two physical-chemical (PC) plants would bring with them all the benefits of clean water, but none of the other impacts cited in this study.

Scheme 2: Tertiary for combined Lowell-Lawrence-Haverhill and Nashua, tertiary for Fitchburg-Leominster; physical-chemical plants elsewhere. In addition to providing clean water, the system would enhance regional economic development in the sense of inter-community cooperation, as well as in providing a more flexible set-up for future water demands of the areas.

Scheme 3: Two large physical-chemical plants. This system would maximize inter-community cooperation in development, and flexibility for future water demand in the region.

Scheme 4: All land disposal with Lowell-Lawrence-Haverhill flow into Maine. This system would yield maximum agricultural benefits (possibly in excess of $500,000 - $1,000,000 cited earlier if Maine benefits are included), but would require relatively little joint planning and long-run flexibility of demand for water, thus limiting the possibilities for long-run development in the region.

Scheme 5: Water: Lowell-Lawrence-Haverhill (T); Fitchburg-Leominster (T); Winnepesauke (PC). Land: Nashua, Concord, Manchester. This system would retain the major agricultural advantages studied in the present paper since most of the agricultural areas in question lie in the area to be irrigated. Regional cooperation effects are likely to be small; water resource research is likely to benefit substantially.

Scheme 6: Water: Lowell-Lawrence-Haverhill (T); Land: Seasonal irrigation at Fitchburg-Leominster (T), Nashua (T), Manchester (PC) and Winnepesauke (PC). This system would retain the agricultural advantages in probably a higher ratio than the land area to be used for disposal would indicate since better site selection would guarantee higher return per acre than the averages used to assess benefits in this study. Regional cooperation may be greater than for schemes 4 and 5.

Scheme 7: Seasonal irrigation at Fitchburg-Leominster; Lowell-Lawrence-Haverhill; Nashua (PC) and Manchester-Concord-Winnepesauke (PC). This system would retain most of the agricultural advantages while permitting a good deal of regional cooperation and developmental flexibility.

From the viewpoint of economic impacts, this analyst would place Schemes 2, 5, and 7 in a position of slight advantage over the other four schemes. Further study is, however, essential before firm rankings can be constructed.

The concluding recommendation of this paper is that a comprehensive study of the area be undertaken to determine potential economic impacts as outlined above. The present results are highly tentative, and should not be construed as adequate for decision-making purposes even from the narrow viewpoint of economic repercussions.

6.1 Location of New Hampshire Manufacturing Plants: 1963

SIC Code	Area and industry	All plants	1-19	20-49	50-99	100-249	250-499	500-999	1,000 or more
	NEW HAMPSHIRE:								
	BELKNAP:								
2024	ICE CREAM AND FROZEN DESSERTS. . . .	1	1						
2026	FLUID MILK	4	3	1					
2051	BREAD AND RELATED PRODUCTS	1	1						
2086	BOTTLED AND CANNED SOFT DRINKS . . .	1		1					
2241	NARROW FABRIC MILLS.	1		1					
2251	WOMEN'S HOSIERY, EXCEPT SOCKS. . . .	3	2		1				
2252	HOSIERY, NEC	4	1	1	1	1			
2253	KNIT OUTERWEAR MILLS	1			1				
2339	WOMEN'S OUTERWEAR, NEC	1	1						
2369	CHILDREN'S OUTERWEAR, NEC.	1		1					
2394	CANVAS PRODUCTS.	1	1						
2399	TEXTILE PRODUCTS, NEC.	1				1			
2411	LOGGING CAMPS AND CONTRACTORS. . . .	5	4	1					
2421	SAWMILLS AND PLANING MILLS	7	6	1					
2499	WOOD PRODUCTS, NEC	1				1			
2511	WOOD FURNITURE, NOT UPHOLSTERED . . .	1	1						
2621	PAPER MILLS, EXCEPT BUILDING	1			1				
2652	SETUP PAPERBOARD BOXES.	1	1						
2711	NEWSPAPERS	2	1	1					
2732	BOOK PRINTING.	1	1						
2751	PRINTING, EXCEPT LITHOGRAPHIC. . . .	2	2						
2752	PRINTING, LITHOGRAPHIC	2	2						
3111	LEATHER TANNING AND FINISHING. . . .	1				1			
3141	SHOES, EXCEPT RUBBER	1				1			
3231	PRODUCTS OF PURCHASED GLASS.	1	1						
3271	CONCRETE BLOCK AND BRICK	1	1						
3272	OTHER CONCRETE PRODUCTS.	3	3						
3273	READY-MIXED CONCRETE	1	1						
3292	ASBESTOS PRODUCTS.	1				1			
3321	GRAY IRON FOUNDRIES.	2	2						
3322	MALLEABLE IRON FOUNDRIES	1				1			
3361	ALUMINUM CASTINGS.	2	1			1			
3429	HARDWARE, NEC.	1	1						
3442	METAL DOORS, SASH, AND TRIM.	1	1						
3446	ARCHITECTURAL METAL WORK	1	1						
3449	MISCELLANEOUS METAL WORK, NEC. . . .	1	1						
3451	SCREW MACHINE PRODUCTS	1	1						
3479	METAL COATING, ENGRAVING, ETC. . . .	1	1						
3544	SPECIAL DIES AND TOOLS	2	2						
3552	TEXTILE MACHINERY.	2	1						1
3553	WOODWORKING MACHINERY.	1	1						
3562	BALL AND ROLLER BEARINGS	1			1				
3565	INDUSTRIAL PATTERNS.	2	2						
3599	MISCELLANEOUS MACHINERY.	2	2						
3613	SWITCHGEAR AND SWITCHBOARDS.	1		1					
3629	ELECTRIC INDUSTRIAL GOODS, NEC . . .	1	1						
3662	RADIO, TV COMMUNICATIONS EQUIPMENT .	2	1	1					
3679	ELECTRONIC COMPONENTS, NEC	1	1						
3931	MUSICAL INSTRUMENTS AND PARTS. . . .	1			1				
3942	DOLLS.	2	2						
3949	SPORTING & ATHLETIC GOODS.	2	1		1				
3964	NEEDLES, PINS, AND FASTENERS	1				1			
3999	MISCELLANEOUS PRODUCTS, NEC.	1	1						
	BELKNAP, TOTAL.	85	50	10	7	9			1

Location of Manufacturing Plants: 1963 (continued)

Ind. Code	Area and industry	All plants (Number)	1-19	20-49	50-99	100-249	250-499	500-999	1,000 or more
	GRAFTON:								
2026	FLUID MILK	[illegible]	[illegible]						
2051	BREAD AND RELATED PRODUCTS	3	3						
2231	WEAVING, FINISHING MILLS, WOOL	2					2		
2283	WOOL YARN MILLS	1		1					
2328	WORK CLOTHING	1				1			
2329	MEN'S AND BOYS' CLOTHING, NEC	1				1			
2335	DRESSES	1		1					
2411	LOGGING CAMPS AND CONTRACTORS	16	16						
2421	SAWMILLS AND PLANING MILLS	15	14	1					
2426	HARDWOOD DIMENSION & FLOORING	4	4						
2429	SPECIAL PRODUCT SAWMILLS, NEC	3	2	1					
2431	MILLWORK PLANTS	2	2						
2441	NAILED WOODEN BOXES AND SHOOK	1	1						
2449	WOOD PRODUCTS, NEC	5	3	2					
2511	WOOD FURNITURE NOT UPHOLSTERED	1			1				
2621	PAPER MILLS, EXCEPT BUILDING	2		1			1		
2631	PAPERBOARD MILLS	1		1					
2649	CONVERTED PAPER PRODUCTS, NEC	1			1				
2652	SETUP PAPERBOARD BOXES	1	1						
2711	NEWSPAPERS	6	5	1					
2731	BOOKS, PUBLISHING AND PRINTING	2	1	1					
2732	BOOK PRINTING	1		1					
2751	PRINTING, EXCEPT LITHOGRAPHIC	3	2		1				
2752	PRINTING, LITHOGRAPHIC	1	1						
2819	INORGANIC CHEMICALS, NEC	1	1						
2834	PHARMACEUTICAL PREPARATIONS	1	1						
2951	PAVING MIXTURES AND BLOCKS	1	1						
3069	RUBBER PRODUCTS, NEC	2	1					1	
3111	LEATHER TANNING AND FINISHING	2	1		1				
3131	FOOTWEAR CUT STOCK	1		1					
3141	SHOES, EXCEPT RUBBER	3				2	1		
3251	BRICK AND STRUCTURAL TILE	1			1				
3271	CONCRETE BLOCK AND BRICK	1	1						
3272	OTHER CONCRETE PRODUCTS	2	2						
3273	READY-MIXED CONCRETE	2	2						
3291	ABRASIVE PRODUCTS	1			1				
3357	NONFERROUS WIRE DRAWING, ETC.	1		1					
3423	HAND AND EDGE TOOLS	1		1					
3442	METAL DOORS, SASH AND TRIM	1	1						
3452	BOLTS, NUTS, RIVETS, & WASHERS	1	1						
3461	METAL STAMPINGS	1	1						
3552	TEXTILE MACHINERY	1				1			
3562	BALL AND ROLLER BEARINGS	1					1		
3599	MISCELLANEOUS MACHINERY	2	1	1					
3642	LIGHTING FIXTURES	1	1						
3679	ELECTRONIC COMPONENTS, NEC	1				1			
3842	SURGICAL APPLIANCES & SUPPLIES	2	1	1					
3911	JEWELRY, PRECIOUS METAL	1	1						
3942	DOLLS	1	1						
3988	MORTICIANS' GOODS	1	1						
	GRAFTON, TOTAL	117	83	16	6	6	5	1	
	HILLSBOROUGH:								
2011	MEAT SLAUGHTERING PLANTS	1				1			
2013	MEAT PROCESSING PLANTS	7	4	1	1	1			
2015	POULTRY DRESSING PLANTS	1			1				
2024	ICE CREAM AND FROZEN DESSERTS	1		1					
2026	FLUID MILK	17	12	2	2	1			
2032	CANNED SPECIALTIES	1		1					
2033	CANNED FRUITS AND VEGETABLES	1			1				
2037	FROZEN FRUITS AND VEGETABLES	1	1						
2042	PREPARED ANIMAL FEEDS	3	1	2					
	NEW HAMPSHIRE (CONT.)								
	HILLSBOROUGH (CONT.)								
2051	BREAD AND RELATED PRODUCTS	10	8			2			
2085	DISTILLED LIQUOR EXCEPT BRANDY	1	1						
2086	BOTTLED AND CANNED SOFT DRINKS	7	4	1	1	1			
2087	FLAVORINGS	1	1						
2094	ANIMAL & MARINE FATS & OILS	1	1						
2099	FOOD PREPARATIONS, NEC	2	2						
2211	WEAVING MILLS, COTTON	1						1	
2221	WEAVING MILLS, SYNTHETICS	4			2	1	1		
2231	WEAVING, FINISHING MILLS, WOOL	3		1	1	1			
2241	NARROW FABRIC MILLS	2	1		1				
2251	WOMEN'S HOSIERY, EXCEPT SOCKS	1					1		
2252	HOSIERY, NEC	1			1				
2253	KNIT OUTERWEAR MILLS	5		1		2	1	1	
2256	KNIT FABRIC MILLS	1		1					
2259	KNITTING MILLS, NEC	1	1						
2261	FINISHING PLANTS, COTTON	1				1			
2262	FINISHING PLANTS, SYNTHETIC	1				1			
2271	WOVEN CARPETS AND RUGS	2	1	1					
2281	YARN MILLS, EXCEPT WOOL	2			1	1			
2283	WOOL YARN MILLS	3	1	1			1		
2284	THREAD MILLS	1	1						
2293	PADDING AND UPHOLSTERY FILLING	1	1						
2297	SCOURING AND COMBING PLANTS	2	1		1				
2311	MEN'S AND BOYS' SUITS AND COATS	1			1				
2321	MEN'S DRESS SHIRTS & NIGHTWEAR	2		1		1			
2328	WORK CLOTHING	1		1					
2335	DRESSES	2	1		1				
2337	WOMEN'S SUITS, COATS & SKIRTS	1	1						
2339	WOMEN'S OUTERWEAR, NEC	2			2				
2341	WOMEN'S & CHILDREN'S UNDERWEAR	1		1					
2361	CHILDREN'S DRESSES AND BLOUSES	1		1					
2369	CHILDREN'S OUTERWEAR, NEC	2		1		1			
2391	CURTAINS AND DRAPERIES	1	1						
2392	HOUSEFURNISHINGS, NEC	3	3						
2394	CANVAS PRODUCTS	2	2						
2396	APPAREL FINDINGS	1	1						
2399	TEXTILE PRODUCTS, NEC	1	1						
2411	LOGGING CAMPS AND CONTRACTORS	8	7	1					
2421	SAWMILLS AND PLANING MILLS	21	18	2	1				
2431	MILLWORK PLANTS	5	2	2		1			
2433	PREFABRICATED WOOD PRODUCTS	2	1	1					
2441	NAILED WOODEN BOXES AND SHOOK	3	2	1					
2442	WIREBOUND BOXES AND CRATES	1	1						
2445	COOPERAGE	1	1						
2491	WOOD PRESERVING	1		1					
2499	WOOD PRODUCTS, NEC	16	10	5	1				
2511	WOOD FURNITURE NOT UPHOLSTERED	5	1		2	2			
2512	WOOD FURNITURE, UPHOLSTERED	5	5						
2515	MATTRESSES AND BEDSPRINGS	3	2		1				
2531	PUBLIC BUILDING FURNITURE	3		2	1				
2541	WOOD PARTITIONS AND FIXTURES	4	2	1		1			
2621	PAPER MILLS, EXCEPT BUILDING	1				1			
2641	PAPER COATING AND GLAZING	1							
2645	DIE CUT PAPER AND BOARD	1	1						
2646	PRESSED AND MOLDED PULP GOODS	1		1					
2651	FOLDING PAPERBOARD BOXES	1		1					
2652	SET-UP PAPERBOARD BOXES	4		2					
2653	CORRUGATED SHIPPING CONTAINERS	1				1			
2711	NEWSPAPERS	10	7	1	1		1		
2721	PERIODICALS	2	2						
2731	BOOKS, PUBLISHING AND PRINTING	4	4						
2741	MISCELLANEOUS PUBLISHING	1	1						
2751	PRINTING, EXCEPT LITHOGRAPHIC	15	14		1				
2752	PRINTING, LITHOGRAPHIC	5	5						
2761	MANIFOLD BUSINESS FORMS	1			1				
2771	GREETING CARD MANUFACTURING	1						1	
2791	TYPESETTING	1	1						
2793	PHOTOENGRAVING	2	2						
2818	ORGANIC CHEMICALS, NEC	1			1				
2821	PLASTICS MATERIALS AND RESINS	2	1				1		
2844	TOILET PREPARATIONS	3	3						
2851	PAINTS AND ALLIED PRODUCTS	1	1						
2872	FERTILIZERS, MIXING ONLY	1	1						
2951	PAVING MIXTURES AND BLOCKS	1	1						
3069	RUBBER PRODUCTS, NEC	4	3			1			
3079	PLASTICS PRODUCTS, NEC	10	2	4	2	1	1		
3111	LEATHER TANNING AND FINISHING	5		2	2	1			
3131	FOOTWEAR CUT STOCK	9	6	2		1			
3141	SHOES, EXCEPT RUBBER	23	4	1		4	6	6	
3161	LUGGAGE	1					1		
3199	LEATHER GOODS, NEC	1		1					
3231	PRODUCTS OF PURCHASED GLASS	1			1				
3269	POTTERY PRODUCTS, NEC	1	1						
3271	CONCRETE BLOCK AND BRICK	3	2	1					

Location of Manufacturing Plants: 1963 (continued)

Ind. Code	Area and industry	All plants	Number of plants with employment of—						
		(number)	1-19	20-49	50-99	100-249	250-499	500-999	1,000 or more
	NEW HAMPSHIRE (CONT.)								
	HILLSBOROUGH (CONT.)								
3272	OTHER CONCRETE PRODUCTS	5	4	1					
3273	READY-MIXED CONCRETE	4	3	1					
3281	CUT STONE AND STONE PRODUCTS	3	1	1	1				
3291	ABRASIVE PRODUCTS	1		1					
3292	ASBESTOS PRODUCTS	1					1		
3321	GRAY IRON FOUNDRIES	2		2					
3323	STEEL FOUNDRIES	1					1		
3341	SECONDARY NONFERROUS METALS	1	1						
3357	NONFERROUS WIRE DRAWING, ETC.	1		1					
3361	ALUMINUM CASTINGS	1	1						
3421	CUTLERY	1			1				
3423	HAND AND EDGE TOOLS	3	1	2					
3429	HARDWARE, NEC	2			1	1			
3441	FABRICATED STRUCTURAL STEEL	1			1				
3442	METAL DOORS, SASH, AND TRIM	3		2	1				
3443	BOILER SHOP PRODUCTS	1	1						
3444	SHEET METAL WORK	4	3	1					
3446	ARCHITECTURAL METAL WORK	1	1						
3452	BOLTS, NUTS, RIVETS, & WASHERS	1			1				
3461	METAL STAMPINGS	2	1	1					
3471	PLATING AND POLISHING	1	1						
3499	FABRICATED METAL PRODUCTS, NEC	3	2		1				
3519	INTERNAL COMBUSTION ENGINES	1	1						
3542	METAL-FORMING MACHINE TOOLS	1		1					
3544	SPECIAL DIES AND TOOLS	3	2		1				
3545	MACHINE TOOL ACCESSORIES	2	1			1			
3548	METALWORKING MACHINERY, NEC	2	2						
3552	TEXTILE MACHINERY	2		1	1				
3553	WOODWORKING MACHINERY	1			1				
3554	PAPER INDUSTRIES MACHINERY	5	3				1	1	
3555	PRINTING TRADES MACHINERY	1	1						
3562	BALL AND ROLLER BEARINGS	1						1	
3565	INDUSTRIAL PATTERNS	1	1						
3576	SCALES AND BALANCES	1	1						
3599	MISCELLANEOUS MACHINERY	17	16	1					
3611	ELECTRIC MEASURING INSTRUMENTS	5	2	2			1		
3613	SWITCHGEAR AND SWITCHBOARDS	1					1		
3636	SEWING MACHINES	1	1						
3641	ELECTRIC LAMPS	1				1			
3662	RADIO, TV COMMUNICATIONS EQUIPMENT	10	3	2		4			1
3674	SEMICONDUCTORS	1						1	
3679	ELECTRONIC COMPONENTS, NEC	8	1	2	1	2	1		1
3694	ENGINE ELECTRICAL EQUIPMENT	1	1						
3699	ELECTRICAL PRODUCTS, NEC	1	1						
3717	MOTOR VEHICLES AND PARTS	1	1						
3732	BOAT BUILDING AND REPAIRING	2	2						
3821	MECHANICAL MEASURING DEVICES	4	2		2				
3941	GAMES AND TOYS	4	2				2		
3942	DOLLS	2	2						
3953	MARKING DEVICES	1	1						
3991	BROOMS AND BRUSHES	1				1			
3988	MORTICIANS' GOODS	6	4	1		1			
3993	SIGNS AND ADVERTISING DISPLAYS	3	3						
3999	MISCELLANEOUS PRODUCTS, NEC	4	4						
--	ADMINISTRATIVE AND AUXILIARY	7	3		2	2			
	HILLSBOROUGH, TOTAL	450	248	73	47	43	24	12	3
	MERRIMACK								
2026	FLUID MILK	5	2	2	1				
2033	CANNED FRUITS AND VEGETABLES	2	2						
2042	PREPARED ANIMAL FEEDS	2	1		1				
2095	ROASTED COFFEE	1	1						
2231	WEAVING, FINISHING MILLS, WOOL	2					2		
2241	NARROW FABRIC MILLS	4	2	2					
2251	WOMEN'S HOSIERY, EXCEPT SOCKS	1				1			
2252	HOSIERY, NEC	2	1		1				
2269	FINISHING PLANTS, NEC	1	1						
2283	WOOL YARN MILLS	2	1			1			
2328	WORK CLOTHING	1	1						
2329	MEN'S AND BOYS' CLOTHING, NEC	1			1				
2335	DRESSES	3		2	1				
2386	LEATHER & SHEEP-LINED CLOTHING	1	1						
2399	TEXTILE PRODUCTS, NEC	1	1						
2411	LOGGING CAMPS AND CONTRACTORS	11	11						
2421	SAWMILLS AND PLANING MILLS	18	18						
2426	HARDWOOD DIMENSION & FLOORING	1	1						
2431	MILLWORK PLANTS	3	1	1		1			
2433	PREFABRICATED WOOD PRODUCTS	1		1					
2441	NAILED WOODEN BOXES AND SHOOK	5	3	2					
2445	COOPERAGE	1	1						
2499	WOOD PRODUCTS, NEC	3	1	2					
2511	WOOD FURNITURE NOT UPHOLSTERED	2	1			1			
	NEW HAMPSHIRE (CONT.)								
	MERRIMACK (CONT.)								
2512	WOOD FURNITURE, UPHOLSTERED	1		1					
2515	MATTRESSES AND BEDSPRINGS	1		1					
2621	PAPER MILLS, EXCEPT BUILDING	1		1					
2631	PAPERBOARD MILLS	2	1	1					
2651	FOLDING PAPERBOARD BOXES	2				2			
2711	NEWSPAPERS	3	2		1				
2721	PERIODICALS	1	1						
2731	BOOKS, PUBLISHING AND PRINTING	1	1						
2732	BOOK PRINTING	2		2					
2751	PRINTING, EXCEPT LITHOGRAPHIC	8	[illegible]					1	
2752	PRINTING, LITHOGRAPHIC	1			1				
2753	ENGRAVING AND PLATE PRINTING	1	1						
2771	GREETING CARD MANUFACTURING	2	1	1					
2789	BOOKBINDING AND RELATED WORK	2	2						
2791	TYPESETTING	2	1		1				
2793	PHOTOENGRAVING	2	2						
2794	ELECTROTYPING AND STEREOTYPING	1			1				
2841	SOAP AND OTHER DETERGENTS	1	1						
2842	POLISHES AND SANITATION GOODS	1	1						
2911	PETROLEUM REFINING	1	1						
3079	PLASTICS PRODUCTS, NEC	1			1				
3111	LEATHER TANNING AND FINISHING	4	1	2			1		
3121	INDUSTRIAL LEATHER BELTING	1				1			
3141	SHOES, EXCEPT RUBBER	2		1			1		
3231	PRODUCTS OF PURCHASED GLASS	1	1						
3269	POTTERY PRODUCTS, NEC	1	1						
3272	OTHER CONCRETE PRODUCTS	3	2		1				
3273	READY-MIXED CONCRETE	1	1						
3281	CUT STONE AND STONE PRODUCTS	2	1			1			
3291	ABRASIVE PRODUCTS	1	1						
3295	MINERALS, GROUND OR TREATED	1	1						
3315	STEEL WIRE DRAWING, ETC.	1			1				
3321	GRAY IRON FOUNDRIES	1		1					
3357	NONFERROUS WIRE DRAWING, ETC.	1			1				
3362	BRASS, BRONZE, COPPER CASTINGS	1				1			
3425	HAND SAWS AND SAW BLADES	1		1					
3441	FABRICATED STRUCTURAL STEEL	1	1						
3444	SHEET METAL WORK	2	2						
3446	ARCHITECTURAL METAL WORK	1	1						
3494	VALVES AND PIPE FITTINGS	1				1			
3544	SPECIAL DIES AND TOOLS	1	1						
3548	METALWORKING MACHINERY, NEC	1	1						
3553	WOODWORKING MACHINERY	1		1					
3554	PAPER INDUSTRIES MACHINERY	1				1			
3567	INDUSTRIAL FURNACES AND OVENS	2	1			1			
3569	GENERAL INDUSTRY MACHINES, NEC	1	1						
3589	SERVICE INDUSTRY MACHINES, NEC	2		1		1			
3599	MISCELLANEOUS MACHINERY	3	3						
3611	ELECTRIC MEASURING INSTRUMENTS	4	1		1	2			
3612	TRANSFORMERS	1	1						
3622	INDUSTRIAL CONTROLS	1	1						
3629	ELECTRIC INDUSTRIAL GOODS, NEC	1		1					
3652	PHONOGRAPH RECORDS	1			1				
3679	ELECTRONIC COMPONENTS, NEC	2	1					1	
3717	MOTOR VEHICLES AND PARTS	1	1						
3732	BOAT BUILDING AND REPAIRING	2	1		1				
3811	SCIENTIFIC INSTRUMENTS	1	1						
3821	MECHANICAL MEASURING DEVICES	1	1						
3842	SURGICAL APPLIANCES & SUPPLIES	2	2						
3941	GAMES AND TOYS	1	1						
3953	MARKING DEVICES	1	1						
	MERRIMACK, TOTAL	169	105	27	16	15	4	2	
2013									
2024									
2026									
2036									
2051									
2086									
2087									
2099									
2221									
2241									
2294									
2299									
2321									
2369									
2394									
2395									
2399									
2411									

6.2 Products and By-Products from Corn Refining: Muskegon Project, Muskegon County, Michigan

Corn being a widely grown and fairly staple commodity has been examined for a number of years for its potential uses. In addition to starch, corn is readily processed into a variety of products including, sugar (dextrine), syrups, oil, steepwater, feel meal, and others. The list given below is one compiled from literature of the wet milling corn refining industry, particularly the Corn Refineries Institute.

An examination of this list reveals quite a variety of products which should indicate to Muskegon County the potential of corn refining as a cycle-oriented industry. This potential is mainly due to the varied corn refining products which provide the potential for linkage to an equally varied group of industries.

Corn Starch

Abrasive paper and cloth
Adhesives (glues, pastes, mucilages, gums, etc.)
Asbestos products
Batteries, dry cell
Binder or binding agents
Board (corrugating, laminating solid fiberboard, etc.)
Boiler compounds
Bookbinding
Briquettes (of coal and charcoal)
Cardboard
Ceramics (as clay binder)
Chemicals
Cleaners
Coatings on wood, metal and paper
Fermentation processes
Fiber glass size
Fireworks
Fish food
Furniture (as an adhesive)
Insecticide powders
Insulating material (glass wool, rock wool, etc.)
Lacquers
Laundry (home and commercial)
Lubricating agents
Metallic-ore processing

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Lactic Acid

Chemicals
Dyes
Esters and salts
Lacquer thinners
Lactates, sodium and calcium
Leather (deliming and pH control)
Paint removers
Plastics and resins
Plasticizers
Softeners
Solvents
Tanning and leather processing
Textile processing

Corn Oil and Free Fatty Acids

Chemicals and insecticides
Lecithin (for pharmaceuticals, cosmetics, paints, linoleum, printing inks, soap, etc.)
Paint and varnish
Rubber substitutes
Rust preventive (surface coatings)
Soap
Soluble oil (leather and tanning use)
Textiles

Steepwater

Feeds, livestock and poultry
Pharmaceuticals and chemicals

Gluten Feed and Meal, Corn Oil Cake and Corn Oil-Cake Meak

Amino acids
Animal feed
Fur cleaner
Zein and other protein products (plastics, synthetic fiber, etc.)

Dextrins (Cont'd)

Shells, shotgun (for paper covering, wad, etc.)
Shoes (counter pastes, polish, etc.)
Silvering compounds
Soaps
Straws (drinking
Textiles, sizing, finishing and printing
Tubes, spiral and convolute
Twine, cord, string, etc.
Wallboard, gypsum
Wallpaper
Window shades and shade cloth

Corn Syrup

Adhesives (plasticizing agent)
Chemicals
Dyes and inks (meat-marking fluid, etc.)
Explosives
Leather tanning (chrome process)
Metal plating
Paper, glassine and parchment
Plasticizer
Polish, shoe
Rayon (viscose process)
Textile, for finishing
Tobacco and tobacco products

Corn Sugar, Refined

Acids, commercial (lactic, acetic, etc.)
Adhesives
Boiler compounds
Chemicals (calcium lactate, sodium lactate, etc.)
Chemicals, organic
Dyes
Electropolating and galvanizing
Enzymes
Explosives
Fermentation products
Florists' preparations
Leather tanning and tanning preparations
Mannitol
Paper manufacture
Rayon
Rubber ("cold process")
Septic tank conditioner
Sizing materials
Sorbitol (highly essential industrial chemical)
Textiles, dyeing and finishing

Hydrol (Corn-Sugar Molasses)

Organic acids
Organic solvents
Tobacco

Coatings on wood, etc. (Cont'd)
- Models, window display
- Oilcloth
- Oil-well drilling (drilling mud)
- Ore refining (electrolytic refaction process, flotation process, etc.)
- Paints (cleaning compounds, coldwater and latex paints, poster, etc.)

Color carrier (in paper and textile printing)
Containers, laminated and corrugated
Cord polishing
Core binder
Cork products
Cord and twine sizing
Crayon and chalk (as a binder)
Detergents
Dispersing and standardizing agent
Dolls, composition
Dressing, surgical
Dyes (as a bodying agent, carrier, diluent, etc.)

Explosives (dynamite, fireworks, flares, nitrated starch, etc.)
Paper and paper products manufacture
Paper converting
Photographic films (antihalation powder)
Plastics (molded)
Plywood (interior)
Printing
Protective colloids (emulsions)
Soaps and cleaners
Textiles (warp sizing and finishing)
Tile, ceiling
Tires, rubber
Wallboard, gypsum
Water recovery, industrial
Window shades and shade cloth
Wool, rock

Dextrins

Abrasive paper and cloth
Adhesives (glues, pastes, mucilages, dums)
Asbestos
Bookbinding
Briquettes
Candles
Carpet and rug sizing
Ceramics
Cigarette package sealing
Cord polishing
Core binder (castings, molds, etc.)
Cork products
Crayons and chalk (as a binder)
Doll heads, molded toys, manikins, etc.)
Drums, fiberboard
Dyes (dry, cake, etc.)
Envelopes
Explosives
Fireworks
Glue, animal (extender)
Inks, printing
Insecticides
Insulation, fiber glass
Labels
Leather
Linoleum
Magazines
Matches (on head and side of box)
Metallic-ore processing
Oil-well drilling
Ore separation
Paints (cold-water, poster, etc.)
Paper and paper products manufacture
Plastics
Plywood
Sandpaper

Carlozzi, Sinton, and Vilkitis Inc.

ANALYSIS OF PROBABLE IMPACTS ON THE AQUATIC ECOLOGY OF THE MERRIMACK RIVER RESULTING FROM PROPOSED WASTE WATER MANAGEMENT ALTERNATIVES

Carl A. Carlozzi, Project Manager

Charles F. Cole
Ralph Mayo
Steven Rideout

I ECOLOGICAL CONCEPTS

Three ecological concepts were used to evaluate the impact of various alternative water treatment schemes: ecological stability, normal bio-production and the photosynthesis/respiration or P/R ratio.

The P/R ratio represents the relationships between the total respiratory action of an ecological system such as the Merrimack River and its total photosynthetic activity. An ecosystem whose P/R exceeds 1 is accumulating photosynthetic products and is probably a young, unstable ecosystem; one whose value is less than 1 is older but is also unstable and can accumulate organic material only if it is imported. Only those ecosystems that are stabilized have P/R values equalling 1.

Ecological stability expresses the self-regulating quality of an ecological system. As a biological community becomes more complex and more inter-relationships between organisms develop, as the numbers of species present becomes greater and as the dominance in numbers of any one or two species decreases, ecological stability tends to increase. It is thus both a factor enhanced by increasing complexity and self-regulating control of the biotic community and one enhanced by the stability of inputs and products from the system. Highly complex ecosystems such as coral reefs tend to be highly stable, highly polluted areas and single species farm fields tend to be highly unstable. As communities develop toward stability, in general terms, they evolve toward a P/R ration equalling 1.

Normal Bio-production. Highly polluted areas tend to accumulate organic material faster than their biological components can oxidize it;

accordingly masses of material accumulate giving the superficial appearance of a high standing crop of biomass. Unpolluted areas in the same geographic areas that are basically ecologically equivalent produce an organic biomass that is more frequently recycled back through a complex biotic structure and therefore is not accumulated though indeed its rate of production may well be equal to that in the polluted region. We have attempted to evaluate the effects of stream quality improvement not only on the likely return of areas toward a greater ecological stability but upon their likely return toward a normal bio-production. This normal production must be that probably present in the region before the impact of man was felt.

II IMPACT VARIABLES

A. Physical

1. Temperature. Temperature has a primary influence on the distribution of species within the ecosystem. Temperature ranges in water are less than on land and aquatic organisms generally have narrower tolerance ranges. Usually upper temperature limits are more critical than lower limits despite the fact that many organisms function more efficiently toward the upper limits. Slight shifts upwards often move species rapidly from a biological suitability to a stress situation. Increasing temperature also regulates community metabolism and is a major factor in creating subgroupings of organisms in ecotypes as outlined in III.

2. Turbidity is caused by the scattering and absorption of light rather than straight line transmission; it is caused by suspended clay, bacteria, solids, plankton and colloids. Light is quickly absorbed in highly turbid streams reducing available sites for production. Moderate amounts of turbidity, depending on the causative agents, usually indicate sufficiency of plankton and nutrient sources; totally clear water is likely to be biologically unproductive. High silt or colloidal loadings are most frequently biologically counterproductive.

3. Water Volume. This is a measure of the amount and timing of water flowing downstream and the pre-impact regimen for the system is considered normative. Conditions that deviate from the normal pattern cause impacts on the biotic community. Decreases in flows will expose

large areas of stream bottom normally covered and can cause a marked increase in temperature and concurrently a decrease in dissolved oxygen. Certain species may rely on high volumes of seasonally available water for attraction prior to spawning runs. Three anadromous fish species (Atlantic salmon, American shad, and the alewife) are native to the river and are being restored following pollution abatement. Loss of attractant waters are very likely to adversely affect their restoration. Flow reduction in reaches downstream from Lawrence will also decrease the available freshwater habitat due to saltwater intrusion up the river.

B. Chemical

1. Nitrogen. Nitrogen in its inorganic forms (nitrates, nitrites and amonia) is important as a nutrient in regulating production; in its organic form it plays an important role in plant and animal metabolism. Sufficient levels of available nitrogen sources are needed in any aquatic system to provide for growth requirements; excess levels may provide too rich a medium and result in nuisance algal blooms and a consequent eutrophication of the environment.

2. Phosphorous. This also is a plant nutrient and exists in the *aquatic enviornment in three forms:* inorganic phosphate, dissolved organic phosphates, and particulate organic phosphates. It is incorporated by plants only in the inorganic form to which the other forms are converted by bacterial action. Phosphorous is an important component of cell structure and must be present in correct amounts with nitrogen as well as other micro-nutrients to promote plant cell

and animal cell growth. Excesses of both nutrients can lead to eutrophication and the subsequent degradation of the aquatic community.

3. Dissolved oxygen amounts in water is a significant factor in determining the community quality and in determining the level of community respiration. A decrease in dissolved oxygen will result in stress for the sensitive organisms leading to a decline in their abundance and thus a shift toward a less diverse and more simplified community. A decline of dissolved oxygen usually occurs with either an over-reproductive community or with one suffering from an excessive import of organic loading. A complete absence of dissolved oxygen will result in anaerobic decomposition of organic sediments with subsequent production of noxious gases. An optimal level of dissolved oxygen is required for the maintainence and development of community stability.

C. Biologial

1. Species diversity. Diversity in an ecological system is both a measure of the total number of species present an an appreciation of the distribution of the total individuals present among those species. Diversity increases both as the number of species increases and as the dominance of the system by only a few species decreases. Thus a coral reef is highly diverse with many different kinds of species and accordingly many different kinds of ways of interacting. As communities therefore become simplified by pollution and lose the more sensitive representatives, they lose diversity.

2. Productivity. This is a measure of the rate at which green plants photosynthesize or fix carbon in the system and is herein expressed in units of fixed $C/m^2/yr$. Productivity, or gross photosynthesis,

is a measure of the system's ability not only to incorporate CO_2 into plant tissue and but also to lock up solar energy into a form that is biologically available. Production in a stretch of river (the rate at which new plant tissue is produced) can be confused by importation to or exportation of tissure from the study area; it can also be difficult to measure since gross production is at all times being decreasing to net production by the respiration of plants and animals in the site. The level of productivity can be limited by the shortage of any single necessary factor (CO_2, light energy, and nutrients among others) though other required items are present in sufficiency. Optimal production for a stretch of the Merrimack River has been assumed to be that existing there prior to man's impact. Stretches of the stream are now heavily overloaded with excess production accumulations; processes that greatly reduce nutrient availability should reverse accumulations as well as reducing present production levels. In the long term, however, processes that continuously remove levels of nutrients below that of the pre-impact stream loading will be detrimental to the optimal production concept.

3 pH is a measure of the hydrogen ion activity of a stream and normally is between 6.5 and 8.5 in normal, natural waters. Streams such as the Merrimack River that drain granitic areas tend to have little buffering ability and therefore are sensitive to pollutional activities that bring about rapid pH changes. Small changes in pH are not normally dangerous to fishes, but they may bring about increased solubility of other pollutants such as cyanide radicals or may tie up other nutrient materials or make them more available. Removal of ions

that add to the buffering capacity of already poorly buffered waters should be avoided from a biological view.

4 Alkalinity in natural waters is a measure of that water's capacity to buffer or to prevent changes in pH due to the addition of acids or bases. The major buffering system in freshwater is the bicarbonate system that neutralizes the addition of acids and bases reducing pH shift and also provides carbon for plant photosynthesis. Waters from granitic basins are likely to be low in calcium and magnesium ions thereby reducing the bicarbonate levels and finally rendering the system vulnerable to pH shift.

III ECOSYSTEM CLASSIFICATION

Two criteria were used to classify the aquatic communities, distribution of benthic organisms and distribution of fishes. Reaches of the Merrimack River were classified as having a bottom fauna consisting of organisms highly tolerant to pollution or slightly tollerant to pollution, according to categories used by Oldaker (1966). No reaches of the Merrimack contained predominantly sensitive benthic organisms. The ecological impact for each specific area was considered with respect to the present distribution of these organisms. Although benthic organisms will be distributed according to their temperature tolerances, the effects were masked by the high degree of pollution at specific points of pollution.

The aquatic community was also stratified into three classes of water temperature using fish species as indications. The reach from Franklin to Penacoak, classified as a cold water community, is characterized by the presence of the Eastern Brook Trout (*Salvelinus frontinalis*). This species will not tolerate temperatures greater than 68°F.

The aquatic community from Penacoak to Manchester is considered intermediate in temperature tolerance, based on the presence of small mouth bass (*Micropteus dolomieui*) and walleye (*Stizostedion vitreum*). The maximum tolerance of these species is not greater than 75°F.

The southern portion of the basin, including the Nashua River is considered a warm water community. The predominant species include

chain pickerel (*Esox niger*), yellow perch (*Perca flauescens*) and pumpkinseed (*Lepomis gibbosus*). Stress does not occur in these species until the water temperature reaches a point greater than 80°F.

IV IMPACT ANALYSIS

Impact analysis is shown in the accompanying matrices and maps. These graphic devices are meant to show impact at two geographic levels: First, changes in the several ecological variables are evaluated to test whether or not the changes tend to improve ecological stability and lead toward some expected level of productivity or cause no appreciable departure from presently existing stability-productivity conditions. The results of this test are then applied to each ecological class (see map) as it exists basin-wide. Second, the above stability-productivity test is applied to changes manifested at specific areas. These area specific changes are shown on the accompanying maps. There is an analysis matrix for each alternative.

A. Water Disposal Systems

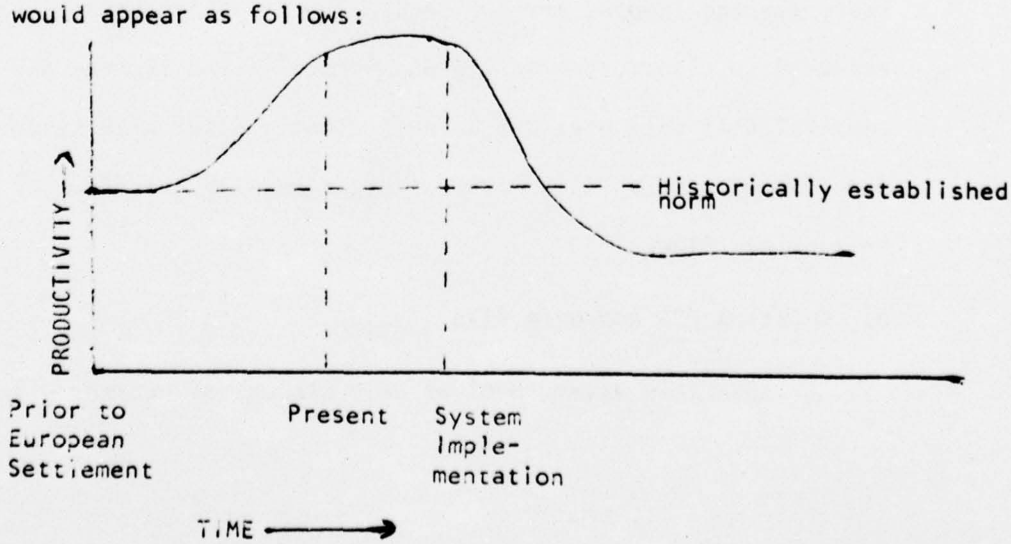
In general the water disposal alternatives have only moderate impact value for improving aquatic ecology in terms of most affected variables. Two major problems seemed to be manifested by the proposed systems: First, there seems to be some likelihood that the almost total removal of nutrients, nitrogen and phosphorous, will in the long run adversly affect the productivity of the river system at all levels of the food chain; second, in alternatives 2 and 3 the changes in stream flow volume resulting from regionalization of waste water plants and/or the export of water outside the basin only exacerbate the problem of summer temperature stress in the river with consequent dissolved oxygen reductions. This loss of flow is especially important to the

warm water communities in the southern third of the basin.

In most instances, with the exception of Alternative #3 in the cold water zone, the water disposal system would probably have a beneficial affect on species diversity, an important factor in maintaining stability.

Existing information on the biota of the basin indicates that the fauna, especially benthic fauna, is impoverished in terms of numbers of species present. Those species which normally would be expected to be present have been extirpated by chemical pollution and sediment loading. All of the water disposal alternatives will assist in restoring species to the river which are now missing due to pollution.

The problem of nutrient decline is interpretable in both the short and long run. Presently, the intermediate and warm water zones are probably over supplied with the basic nutrients, nitrogen and phosphorous, causing a eutrophic condition. In the short run the elimination of the nutrient levels, then physical/chemical treatment will alleviate this problem. In the long run, however, there is a strong possibility that an accumulative nutrient deficiency will result in lowering productivity below normally expected levels. In graph form this phenomenon would appear as follows:



B. Land Disposal System

The land disposal alternative appears to have a beneficial effect only in the intermediate community.

The water diversion to the irrigation field in southeastern New Hampshire will likely perturb the warm water community in the main stem of the river, intensifying the temperature and nutrient deficiency stresses and resulting in a lowered productivity in the warm water zone.

C. Combination Land and Water Disposal Systems

All of the combination systems seem to aid in restoring the river to a stable and normally productive condition. The likelihood that nutrient removal may not be as nearly complete as in physical/chemical systems may be considered desirable in long run productivity potentials in all ecological classes. The absence of any diversion of water out of the basin and the spreading out of effluent discharge to the river offers a guarantee of little disturbance in water flow throughout the main stem.

Temperature effects seem especially beneficial in Alternative #3 where storage lagoons are not required. Effluent temperatures may be expected to rise during spring and summer in the lagoons and it seems doubtful that this heat can be sufficiently dissipated by movement through the soil in either irrigation with ground water management or overland flow.

D. Existing EPA Approved Plan

Because this sytem involves only biological secondary treatment,

the essential impacts would be similar to those caused by primary treatment effluent.

Some relief from BOD loading is accomplished but high nitrogen and phosphorous discharge would likely result in increased bio-productivity leading to eutrophication. Retention of waste water in conventional settling tanks offers a probable temperature rise which would adversely affect river water temperatures and dissolved oxygen during the critical summer period.

In general this system would have little appreciable affect on the present ecology of the river except for some improvement in species diversity as organic waste sediments are reduced.

ALTERNATIVE NUMBER 1

Water disposal

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	+	+	0	1- / 0	0	1- / 0	+	0	+	+	+	0	+
Intermediate Communities	-	-	0	+	0	0	+	3- / 0	+	+	+	2- / 0	+ to 0
Warm Water Communities	-	-	0	+	0	0	+	0	+	+	+	-	+ to -

Area Specific Impact (See number keyed to map)

General Impact for Basin

Impact Value

+ = Change toward greater ecological stability

0 = No appreciable effect

- = Change toward lesser ecological stability

ALTERNATIVE NUMBER 2
(WATER DISPOSAL)

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	+	+	0	+	0	(4) − / 0 TO −	+	0	+ (1) / +	+	+	0	+
Intermediate Communities	(5) − / −	(5) − / −	0	(6) − / +	0	−	+	(2) − / =	+	+	+	0	0 TO −
Warm Water Communities	−	−	0	−	0	−	+	(3) 0 / ≡	+	+	+	−	−

Area Specific Impact
(See number keyed to map)
General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
- = Change toward lesser ecological stability

ALTERNATIVE NUMBER 3
(WATER DISPOSAL)

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	+	+	0	+	0	(1) – / 0 TO –	+	–	(2) + / 0 TO +	0	0	0	0 TO –
Intermediate Communities	+	+	0	+	0	0	+	0	(3) + / +	(3) + / +	(3) + / +	– TO 0	+
Warm Water Communities	–	–	0?	–	0	–	+	≡	+	+	+	–	=

Area Specific Impact
(See number keyed to map)
General Impact for Basin

Impact Value

+ = Change toward greater ecological stability and approaching normal bio-production potentials
0 = No appreciable effect
- = Change toward lesser ecological stability and/or reducing bio-production potentials

ALTERNATIVE NUMBER
L-W #1

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	+	+	0	+	0	1+ / 0	+	2- / 0	+	+	+	+	+
Intermediate Communities	+	+	0	+	0	0	+	0	+	+	+	+	+
Warm Water Communities	+	+	0	+	0	0	+	0	+	+	+	-	+

Area Specific Impact (See number keyed to map)

General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
- = Change toward lesser ecological stability

ALTERNATIVE NUMBER 2

L-W Combination

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	1 0 / +	1 0 / +	/ 0	/ +	/ 0	2 − / +	/ +	3 − / 0	/ +	/ +	/ +	/ +	+
Intermediate Communities	/ +	/ +	/ 0	/ +	/ 0	4 − / +	/ +	/ 0	/ +	/ +	/ +	/ +	+
Warm Water Communities	/ +	/ +	/ 0	/ +	/ 0	/ +	/ +	/ 0	/ +	/ +	/ +	/ +	+

Area Specific Impact
(See number keyed to map)

General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
- = Change toward lesser ecological stability

ALTERNATIVE NUMBER 3

Combination L + W disposal (no storage lagoons, winter P-C, summer irrigation)

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	0	0	0	+	0	+	+	0	+	+	+	+	+
Intermediate Communities	+	+	0	+	0	0	+	0	+	+	+	+	+
Warm Water Communities	+	+	0	+	0	1– / 0	+	2– / 0	+	+	+	1 / +	+

Area Specific Impact
(See number keyed to map)
General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
– = Change toward lesser ecological stability

ALTERNATIVE NUMBER : **LAND DISPOSAL**

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	0	0	0	+	0	+ (1) / 0	+	− (2) / 0	+	0 TO +	+	0	− (3) / 0
Intermediate Communities	−	−	0	+	0	+	+	0	+	+	+	−	+
Warm Water Communities	−	−	0	+	0	+ (4) / −	+	−	+	+	+	−	−

Area Specific Impact
(See number keyed to map)
General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
− = Change toward lesser ecological stability

ALTERNATIVE NUMBER

E.P.A. Approved States' Plan

ECOLOGICAL VARIABLES / ECOLOGICAL CLASSES	NITROGEN	PHOSPHOROUS	TOTAL ALKALINITY	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY	WATER VOLUME	BOTTOM SPECIES DIVERSITY	FISH SPECIES DIVERSITY	PLANT SPECIES DIVERSITY	PRODUCTIVITY: gm. of fixed carbon/M^2	SUMMARY
Cold Water Communities	–	–	0	–	0	–	+	0	+	0	+	+	0
Intermediate Communities	–	–	0	–	0	–	+	0	+	–	+	+ to 0	0
Warm Water Communities	–	–	0	–	0	0	+	0	+	+	0	0	0

Area Specific Impact (See number keyed to map)

General Impact for Basin

Impact Value

+ = Change toward greater ecological stability
0 = No appreciable effect
- = Change toward lesser ecological stability

V SUMMARY EVALUATION

A. Overall the land-water disposal combination alternatives seems to offer the most beneficial impacts on all classes of the Merrimack River's ecology. One of the most important factors in coming to this assesment is the wide-spread arrangement for returning treated effluent to the river, thus avoiding either localized or general alteration of water volume-flow characteristics.

B. The most disadvantageous alternative is the highly regionalized water disposal system #3. This system has only two major points of effluent discharge coupled with a water diversion to Boston.

C. Generally effluent produced by the physical/chemical alternatives has too low a content of nitrogen and phosphorous.

D. All the proposed alternatives will tend to improve species diversity throughout the main stem of the river.

VI IMPACT FACTORS NOT COVERED BY THE EVALUATION SYSTEM

A. Total alkalinity

This variable is important in the chemical environment of aquatic organisms. No analysis was possible since information was not available on levels of alkalinity for either the water of the Merrimack or the effluent from the proposed treatment systems. It would be desirable to conduct research on both of these water conditions. Since alkalinity levels effect osmotic regulation and oxygen metabolism in fishes, more could be understood about impacts and possible management regarding fish productivity.

B. Anadromous Fish

The Merrimack River supported anadromous fish populations prior to the construction of dams on the main stem and the lowering of water quality from pollution. In general, it is believed that with a reduction in pollution levels and the installation or modification of fishways at the dam sites, Atlantic Salmon and American Shad are the species which could be managed. It appears, however, that some of the proposed systems may hinder rather than help achieve the fish restoration management goal. Those systems which suggest a diversion of water from the River could possibly reduce river current strength below the level required for migratory stimulus and orientation. Also the reduction of chemical loading on the river through treatment may alter the chemo-stimulants to migratory movement.

VISUAL ASPECTS AND IMPLICATIONS
OF WASTE WATER MANAGEMENT ON
THE MERRIMACK RIVER

(a preliminary assessment)

FOR: Division Engineer
North Atlantic Corps
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Rivers must have been the guides which conducted the footsteps of the first travelers. They are the constant lure, when they flow by our doors, to distant enterprise and adventure; and, by a natural impulse, the dwellers on their banks will at length accompany their currents to the lowlands of the globe, or explore at their invitation the interior of continents. They are the natural highways of all nations, not only leveling the ground and removing obstacles from the path of the traveler, quenching his thirst and bearing him on their bosoms, but conducting him through the most interesting scenery, the most populous partions of the globe, and where the animal and vegetable kingdoms attain their greatest perfection.

Thoreau

A Week on the Concord and
Merrimack Rivers

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INTRODUCTION

The purpose of this report is to identify, describe and assess the major aesthetic impacts of alternative treatment proposals upon the river and its immediate landscape context. It is intended to be a general broad brush statement upon such issues and will not be site specific in relation to the physical components of the plans. It will emphasize the visual and preferential considerations of the expense of the other senses due to time and data availability.

A comment should be made regarding its length and organization. It is felt that the first attempt at discussion of this subject has produced a paper that is too long and difficult to read. However since time was limited a more concise version could not be written.

James Baldwin once stated in another context "as long as the water is troubled it cannot become stagnant". Observations of the Merrimack suggest that we have not been troubled until this point in time and the water has literally become stagnant.

General comment suggests that once again it is important to qualify the work that follows as being openly subjective in parts and necessarily vague in reference to the landscape and proposals being discussed. This stage of the project and the availability of useful data forces this decision.

The Merrimack River and its landscape context is <u>not</u> visually

unique beyond the river boundaries. It is a typical New England river in a typical New England landscape. It's lack of identified uniqueness does not eliminate all of its values to society, only one of those values. Other values such as existence value, locational value, character value, and multifunctional (composite) value are not eliminated by such a discovery. The Merrimack is just now receiving its due attention to have these values revealed. For a river of its size and length, it has a surprisingly short supply of cultural artifacts. This is all the more reason to make the values of those that do exist tangible to society.

The Merrimack River is a tremendously underused visual resource. The glib comments of the "cities turning their backs on the river" are alarmingly true. Beyond the cities visual and physical access generally restricted and very little riverfront development exists. There is very little evidence of use. Almost no one was observed on or along the river. Subdivisions stopped short of the river edge, not even affording themselves a view. The fact that it is a physical entity is only remotely recognized as highways, powerlines, agriculture, and urbanization often in the proximity of the river do not respond in any way to its presence, by capturing its view, providing access, echoing its alignment, etc.

The Merrimack is of sufficient size and is significantly uniform

along its length in river width, gradient of the river bed, the amount and type of vegetative edge, the embankment characteristics, the alignment characteristics etc. to make it difficult from general data to classify it into character zones. The tributaries to the Merrimack, however, are visually rich and varied and contrast the character of the main stem river.

The major remaining method of classifying the river at the large regional scale, would be to characterize the type of landscape context it flows through. The forested hillsides and embankments predominate along the entire length of the river. The second largest category would be the openland (crop and pasture) agricultural lands. The third major category would be the urbanized areas that abut the river. The Merrimack has few dramatic dams, rapids, waterfalls and other features of interest. It flows along gaining a major portion of its visual character by reflecting the landscape that it flows through.

Despite its macro scale visual uniformity it does offer variation to the hiker and slower moving canoer at the detail viewing scale. On this scale the rivercourse responds to seasonal changes by changes in river level and river flora, as well as generating general all-season interest by the river fauna. This becomes very important in a landscape deficient in water bodies.

The Merrimack River preserves a natural open space above the river itself that is extremely valuable in the heavily expanding forest landscape. In spite of the forested conditions, most of the Basin's open space lies along the river and thus the immediate landscape context is one of the most quickly changing in visual appearance of the entire basin. The river is a permanently preserved open space and is increasing in visual value day by day as the surrounding open land is developed or reverts to forest.

Lakes and wide rivers allow you to aggregate visually a series of landscape elements not otherwise visable in composition. The Merrimack has the outstanding example of Lake Winnipsaukee to demonstrate the ability to make mountains, islands, boats, shore line, towns and various sized spaces a part of one view. The northern Merrimack River is too narrow to do this on a large scale and the southern river, although wider in sections, is located in a flatter topography and does not have the potential for aggregation as the upper river landscape does. The Merrimack looks visually clean when its biological analysis clearly demonstrates it is not. Water is aesthetically clean long before it is biologically clean. The majority of the river presents no visible bathtub ring other than what one might expect to encounter under natural water quality conditions. The river from Manchester down, and most particularly from

Nashua down, does present visually dirty water that alienates. Once it reaches Lawrence and Haverhill it is visually distressing and alienates all but the long distance viewer.

THE DEEP AESTHETIC

People can make a great many primary sensory decisions as to whether a body of water is of clean quality, but the strong judgements on the aesthetic quality of water body are arising from past associations, both conscious and subconscious. As man has changed the use of the rivers as a partner in man's survival to a servant for the disposal of wastes he has concurrently changed his deep aesthetic notions of rivers.

Man's response to the Merrimack River has been in its use as a transportation system for his wastes. His intensity of involvement stopped at the end of his outfall pipe, for he saw fēr other uses for his river. Man is about to attempt to reacquaint himself with the river and its possible other uses. He is willing to remove the physical and mental barriers caused by his neglect of the river, that technology can be made to change the physical barriers to the use of the river is an exciting hope. To see if it can change the mental barriers to use is equally as necessary, both to help justify the expense of the technology and to move man back into a healthy relationship with his water bodies.

Man has both active and passive needs for his waterbodies. The active uses are easy to cater to as their demands are well known. What is not so well known is man's passive needs (deep aesthetic needs) for the riverscape. These needs are difficult to pinpoint, for they only become conspicuous by their absence.

In describing the positive deep aesthetic we must turn to a whole range of emotion laden adjectives; such as clean, free, healthy, violent, strong, roaring, etc. Man has long associated with rivers in their natural state a guarantee of cleanliness, no matter what history may tell us. In examining a stream, man draws on four primary variables to make his decision on the quality of the water. They are color, clarity, odor, and taste.

Mountain streams are used very often in advertising because of man's strong associations with them. The mountain stream stereotype does not include an association with man made structures bordering or impinging upon its shoreline or flow, but rather demands a completely natural setting in which a clear, odorless, colorless, tasteless stream can rush and roar through and over rocks. People are thus using mountain stream characteristics as a baseline for judgement on the aesthetic quality of rivercourses, which may work when dealing with water quality as the work for the deep aesthetic quality. Therefore, people's aesthetic experiences are not completely obtainable for a typical

New England river, such as the Merrimack, as it will never completely fit the mountain stream stereotype with its kaleidoscope of sensual appeal.

The negative deep aesthetic has the antithesis of the mountain stream as its stereotype. Responding to the four primary variables, man rebels at a "dirty" water color such as a red brown; at the inability to see into the stream and observe sub-surface conditions; at floating surface material such as algal scum; at smells eminating from the water or from rotting deposits along the shoreline; and at tastes that do not please.

The reaction to these variables leads to development of a characterization based on conscious and sub-conscious associations. The negative stereotype is of a stagnant water body, with almost every observation applicable to the mountain stream stereotype having its opposite number displayed in the stagnant water body stereotype. Tepid, murky, odorous, filled and surrounded by unnatural elements, incapable of life support, non-moving, foul; words that contribute to the image and reflect associations. A stagnant water body represents death to a portion of our environment.

YESTERDAY

"The Indian tell us of a beautiful river lying far to the south, which they call Merrimack" Sieur De Monts, Relation of the Jesuits, 1604.

The wilderness was the sworn enemy of the pilgrims, and, armed with God, they struck out into the unknown along the only roads that they could travel upon, the river. It thus served as a highway to the interior, being used by the first explorers and later the French trappers. The sites of many of the present communitiessalong the Merrimack were once Indian camping grounds. (The Indians resorted in the fishing season at Lowell.) Topography was the definite control on where settlements grew up, especially in the 18th century when mill sites demanded a water fall. Fields began to open up on the sides of the river as the available open lands bordering the river became farmland. By the mid-19th century the farms had pushed back the forest vegetation to where it was no longer the dominant feature. This released the river from its task of providing the only secure continuum of open space. Its importance as a transportation and water power source still remained high, and in face was growing. In the early 19th century the first major restraining structures were put up on the Merrimack. These consisted of dams and locks and thereby allowed canal blates to run as far as Concord, New Hampshire. A great deal of fishing took place in the lower reaches of the river as well as the development of a tremendous industrial center at Lowell, Massachusetts. The character of the river has changed. It is no longer free to run unimpeded to the ocean with a consequent loss of its aesthetic character of freedom and a

physical loss of its anadromous fish popluation, It becomes the proud showcase of man who proudly displays his factories along its edges, and transports its goods along its length. But it has slowly acquired another function, that of a transporter of the waste from the processes necessary to produce those goods. Its value as a transporter of goods diminishes with the introduction of a railroad system to the river basin corridor. In the rapidly expanding urban centers the shine wears off the factories as has the charisma off the industrial revolution. The rich people in these urban centers begin to retreat from the river, building their houses above and behind the towns. Class identification begins to relate to distance from the industries on the river. The cities start to isolate certain areas for certain functions, such as the river front for industry. During the middle and late 19th century farmlands have become abandoned with the cycle of vegetative succession back to forestland beginning. Nature and economics have taken the marginal farmlands and started to repair their surface erosion, while the rich bottomlands stayed in farm production. The character of the views from the river out to the surrounding countryside are therefore in a state of change from 1800 to 1900. The highest aesthetic quality for land is a ratio of 65% open land to 35% forest, a condition which existed in about 1800. After 1800 the visual quality dropped in direct relation to the deforesting

of the hills, and only began to rise again when farms were abandoned to forest. Around 1900 the visual landscape gained in quality due to well developed forest but was moderated by the poor open space to forest ratio. The view of the river gains visual value when it is in sharp contrast with the contextual landscape. Open fields do not contrast much with open river. The best contrast from this viewpoint is open riverscape versus forested land. Therefore, the area between the cities along the river is in a constant state of change from 1800 to 1900 moving in and out of periods of high visual quality. The area in the cities proper, however, exhibits a strong and constant decline in visual quality as further paraphenalia of industrial expansion crowds the shoreline and there is further dumping of more and more noxious wastes into the river. The cities have very effectively turned their backs on the river.

AESTHETIC BASELINE:

WINNIPESAUKEE RIVER

The Winnipesaukee River is a clear watercourse of from one to four feet in depth with slow to quick movement. It has numerous exciting river falls, from riffles to waterfalls, as well as a large variety of sport fish. The bed ranged from sand to rock with bottom flora easily visible through the clear water. A great variety of birds, including herons congregated along the shoreline which has a good contrast

between open and vegetated stretches. The alignment of the river was curvilinear with excellent variety in the edge configuration. The river varied from 50'-125' in width allowing a good sense of detail and an identity of place to occur. In the town of Tilton the visual contrast with urbanization was very poor, while in Franklin the river was vegetated right up to almost the center of town and in the town had a high quality contrasting shoreline. Generally, the Winnipesaukee River is of high aesthetic quality although it is still quite visually inaccessable.

MERRIMACK RIVER FROM FRANKLIN TO AND INCLUDING MANCHESTER.

The color of the water in the Merrimack ran from clear to reddish brown with some spectacular color displays at some outfalls in urban centers, especially at Manchester. The water clarity ranged from very clear below Franklin to murky in sections of the Merrimack in Concord and Manchester. The river's width was approximately 200-300 feet wide until its confluence with the Contocook, after which it varied between 300 and 700 feet. Some of the wider sections provided an opportunity for panoramic views, although local topography is not of the magnitude of usual interest as in the Winnipesaukee region. The river is slow and sluggish generally, although at specific points, fortunately mostly near urban centers, the river speeds with dams and falls providing visual interest. In this section of the river there is not the variety in fauna found further

north with a consequent sparse amount of recreational fishing. The river was generally of straight alignment with consequent poor visual quality. Exceptions to this are to be found above Penacook where it was curvilinear and in, above, and below the city of Concord where it was both curvilinear and in, above, and below the city of Concord where it was both curvilinear and had numerous ox-bows. The water land contrast is generally high along the river, although visual access is so limited that the contextual river landscape is rarely seen. Within the urban centers the water land contrast, which ranges from poor to excellent, is only visible from crossing points and from behind factories. Generally, because of uniform vegetation, sluggish flow, and a poor contextual landscape, the Merrimack between Franklin and up to and including Manchester is of poor to mediocre visual quality with some noted exceptions.

MERRIMACK - FROM MANCHESTER TO AND INCLUDING NASHUA.

This section of the river is extremely similar to that immediately above Manchester. The noted exceptions are of less consequence and occur less often that they do above Manchester with a consequent drop in the overall character of the river. Manchester's pollution load causes additional murkiness below the city but is soon dissipated. Perhaps the most unusual aspect of this river is the almost incredibly poor visual and physical access to it. The railroad right of way maintains its distance from the river and from the road thereby effectively splitting man off from the river. Generally, the Merrimack from

Manchester to and including Nashua is of poor aesthetic quality with the land water contrast and its existence value as a water body being its two main positive points.

MERRIMACK - NASHUA TO AND INCLUDING LAWRENCE

Up to the town of Tyngsboro the Merrimack retains the same character, however, below Tyngsboro the river begins to change its alignment characteristics rather radically, It swings generally eastward and then to the north to Lawrence. It gains in aesthetic quality as the river moves from a straight to a curvilinear alignment. Although there is very little topographic variation for this alignment to reveal, there is a great deal of urban landmarks, such as the rather ornate mill towers of Lawrence and Lowell. The land water contrast is also of rather high visual quality due to both the quality of the edge and the ability of the massive mill buildings to afford closure on the riverscape. Canals and dams provide both good detail viewing and a sense of visual excitement from a distance. The width of the river, especially above the dams, is also conducive to panoramic views. Unfortunately, the negative aspects (the poor biological quality of the water as well as the litter problem) is lessening the visual quality of the shoreline. Generally the Merrimack River between Nashua and up to and including Lawrence is of medium visual quality on the large landscape contextual scale, but remains in poor aesthetic quality in the micro-scale due to poor biochemical characteristics. It has a strong aesthetic existence

quality, with great potential as it is so close to an urbanized belt.

NASHUA RIVER

The clarity and color of the water in the Nashua has a wide range, with the generally applicable rule that where it passes through urbanized areas it is of low visual quality. This is extremely apparent in the North Branch where it comes out of Fitchburg gray in color from paper pulp process affluent. Most sections of the river are between 50-150 feet in width and maintain an intimate quality. This is further heightened by the rich variety in river fauna and flora as well as the highly interesting edge configuration. The quality of the alignment varies from low to high as it moves from almost straight to curvilinear. Ox-bows, islands, and dams provide further interest in the riverscape. Mostly the river sits in a natural corridor where river land contrast is not high but where edge quality has large importance. Due to its sluggish flow in many parts, it has little visual quality except as due to ephemeral conditions. Visual and physical access to the river ranges from poor to high. Outside of Nashua the road maintains about a 1/4 mile distance from the river allowing a good sequence of views. Generally, the Nashua River displays a wide range in the quality of both its micro-scale and its macro-scale from an aesthetic quality viepoint. It can range from high to low aesthetic quality in a mile distance.

CURRENT PROBLEMS

The current major problems can be surmised from other portions of the text and at this point are only listed in simple form.

- the river is both visually and biologically polluted below Manchester.
- physical and visual access is limited along much of the river, especially intimate contact.
- the river is rather monotonous and needs visual excitement points at intervals along its length.
- needs the addition of variety to as many of its easily controlled variables as possible.
- functional uses and meaning must be ascribed to the Merrimack if the attendant visual use is to be increased.
- the elimination of open land must be stopped and additional open land created from woodland, especially on hillsides back from the river.

AESTHETIC ANALYSIS

MAJOR ATTRIBUTES

In analysis of a particular environment or environmental component normal procedure would involve empiric testing based upon past testing and professional prediction. There has been little testing of the visual riverscape.

Discussion of the Merrimack riverscape will thus be based upon two factors, past planning and design experience and related visual testing.

What has been proven in the past is that it is possible to test for preferences, and to identify some major attributes that are commonly agreed upon as a basis for preference. In this light it is obvious that some portions of the Merrimack landscape would be preferred over others. This could be determined by the appropriate studies.

The following randomly ordered statements identify major variables that are strongly suspect and those that have been proven to influence visual quality and preference. These statements are related to the bibliography where appropriate and explained in the context of the Merrimack River.

Mr. Craig Halverson in his graduate thesis has proven our long standing convictions that people consistently prefer landscapes with water over those without water. The The Merrimack is thus visually important. Diversity, variety, heterogeneity of many types is constantly cited as a key attribute of pleasing environments.

The greater the homogeneity of any landscape at any scale of viewing (regional to detail) the greater the potential of water being in dramatic contrast to that landscape. The

predominently forested Merrimack is more likely to be in strong contrast to the river than the combined open land, forest, agricultural landscapes in smaller portions of the basin.

Another way of explaining this variable might be that the greater the amount of components generating variety, the less visually important each component is to achieving that value.

The most preferred variety has been suggested to be those landscapes dominated by natural elements and contrasted by a small proportion of cultural artifacts. Natural landscapes are thus most preferred but man appears to be reassured of his powers to see his influence on that landscape.

Variety in movement and potential viewing positions is also a way of measuring visual interest. If the movement is more nearly two dimensional such as in the flatter landscapes of the lower basin, the variety in the visible pattern, including that generated by the river, becomes more important. In the more three dimensional movement through mountain landscapes the pattern becomes less important to visual quality. This suggests that where the population concentration exists the Merrimack River has the greatest potential for visual importance.

Mr. Raymond Dasman says, "The rate at which time seems to pass depends upon the density of events that transpire and the degree to which they are related to each other." In other words many unrelated events (diversity) in a short viewing time appear to make time go more quickly and few unrelated events (monotony) appear to make time go more slowly. If one wishes to have time pass quickly, surround yourself with a richly diverse landscape.

Shafer and Mietz have concluded from their study of wilderness trail scenery that variation of trail scenery is the most important demand of wilderness trail users, again supporting the diversity hypothesis. To maintain interest rather than succumbing to stimulation overload the optimum amount of variety must be achieved. Rapport suggests that agreeable variation from repetition is the method of holding viewer attention. We might assume that sensory overload is nowhere near being reached on any of the rivers in the Merrimack with the most variety being presented in the tributaries and the least on the main stem of the river, almost approaching monotony.

Open land has been analyized by Burns and Rundell, and the conclusion from their graduate thesis is that the greatest preference is for landscapes with some open land. Water bodies as suggested earlier, provide one permanent form of this openess. The Merrimack has minimal quantities of

open land which is generally located near the river itself. Increase in open land including that of the river is desirable.

It has been discovered that as topographic change increases, the value of open land as a determinant of preference is reduced. This would suggest, very fortunately, that there is less need for open land in the northern most portions of the basin.

Contrast is another issue that receives attention in regard to landscape quality. In a riverscape this contrast most often takes place on the land/water edge so both of these issues will be discussed jointly.

Mr. Sam Melillo has discovered that rugged sharp edges are preferred over those that are smooth and softened by vegetation. These edges make the landscape structure more visible and comprehendable. In the wooded Merrimack landscape there are few opportunities for edge contrasts as sharp and distinct as a river edge. The Merrimack unfortunately for much of its length has its edge softened by vegetation and the views to the river limited by that same vegetation.

The edge configuration of the water body also has a strong relationship to the visual impression and impact of the water body. A smooth regular shore line that can be easily observed at one glance has less visual impact than an irregular

shoreline that reveals itself segmentally as one drives or walks along it. The fact that it takes more effort and time to see the entire shore line may be construed as some measure of the amount of visual impact a particular water body has on a person.

Mr. Paul Sprelregen has discussed spatial enclosure, another form of edge measurement. A ratio of 1:4 to 1:1 is devised to show the point at which enclosure is lost and the point at which full enclosure is attained. The area of measurement for enclosure would vary with the viewer position. In the Merrimack River there are very few examples of full enclosure and most often the threshold of enclosure is lost for the immediate landscape context of the river. The quality of the river may be increased in specific locations through construction of buildings to achieve full enclosure.

Contrast which is measured along edges and by spatial enclosure can be achieved in the specific sense by isolation of features, by significant size variation between features, by topographic distinction and clarity, through silhouettes and through significant surface material variation. The Merrimack River could benefit from additional examples of each type of contrast along its entire length.

The scale is thus apparent, contrast increases visual stimulation and excitement, and as sharpness in contrast is

decreased (reduce height of topographic or vegetative change or change from conifer to deciduous vegetation) the visual contrast with the river decreases and visual interest decreases.

Rabinowitz and Coughlin and Peterson have discerned that quality of maintenance is the key variable in the preference for landscapes. They have discovered that dislike for a landscape was most often caused by one element in a landscape while preference was supported by a composition of elements. If this is further supported, the elimination of pollution traces and the maintenance of the river context would be extremely significant to the visual enhancement of the Merrimack River.

R. Burton Litton describes viewing height and distance as additional attributes of the preference for landscapes. If one can vary the height of his visual access from a viewer inferior through a normal viewing position to a viewer superior position and provide varied viewing distances from foreground through middle ground to background, he is most likely to find visual pleasure in any landscape. The Merrimack River offers minimal viewer variation from the river itself and the variation of viewing from the context is greatest in the northern topographically varied basin and best in the southern flat land landscape.

One can also discuss views as to the type of information they divulge. Glimpses offer expectation views, panoramic views from a superior position offer orientation views and inferior detailed views could be labelled experiential views. To facilitate these views variety in the attributes just mentioned is necessary plus the addition of planned visual and physical access.

To summarize the attributes of a pleasing river scape we might hypothesize the following:

- .visible water.
- .variety of natural landscapse components.
- .topographic change.
- .a repetitive theme within the variety of elements.
- .some open land.
- .sharp contrasts especially on land/water edge.
- .irregular edge configuration and curvilinear alignment.
- .variation from full enclosure to no enclosure.
- .varied viewing height and distance.
- .good physical/visual access.

POTENTIALS FOR AESTHETIC IMPACT

The senses which are most frequently employed by man are sight, hearing, and touch. Because of the nature of water, man is much more likely to use his sight first and then his sense of smell; the senses of hearing, feeling, and taste are of secondary importance. The sense of smell becomes of prime importance because man is not always able to judge the quality of a water body by sight alone, he must smell the body of water to see if what seems to look clean actually smells clean. This is especially important when the water body contains what are mostly invisible but dangerous elements: infectious agents such as bacteria and viruses; or radioactive waste from power plants or natural sources; or toxic materials such as heavy metals, herbicides, or insecticides; or heated water from industries using the water for cooling. In these cases man can not visually observe the direct characteristic, but he can observe the manifestations of their negative aspects on fish, birds, and plant life. Algal blooms and hot vapors may originate from the hot spots caused by the heated water discharges. The smell of dead and rotting fish may herald a poisonous element in the water. Man is forced to allow the river's flora and fauna to show him what his own eyes can not, that the river body which to all signs was not polluted, was actually laden with undesirable elements. This inability for man to trust his own senses to evaluate cleanliness breeds an unfamiliar fear of the unseen, the unheard, and the unfelt.

Bio-stimulants can cause excessive algae blooms and a speed up of the process of eutrophication. This is both unpleasant visually as well as causing objectionable odors. Algae blooms change both the color and the surface quality of the water, as well as leaving a deposition of algael slime on objects extending up in the water and along the shoreline. People immediately associate algae and dirty water. An algael condition almost always makes body contact sports far less pleasurable. It can also effect the taste of drinking water. When D.O. drops to below levels necessary to sustain aerobic conditions we can expect odors from decaying plant and animal life from the benthic deposits at the bottom of the river. This anaerobic condition also means that sport fishing can no longer be considered a viable recreational activity as at least 5 ppm of D.O. is necessary to sustain the more desirable fish.

Suspended solids are an indication of the strength of wastewater and are therefore usually associated with polluted waters. When conditions permit, they will settle out of the water creating deposits of sludge which not only do not feel good under foot but also give off obnoxious gases when it decomposes. Two other associations which are usually made with dirty water are a sulphurous smell and a dirty color to the water.

Turbidity may come from growths of algae and other plankton organisms, thereby imparting a change in the water color. Muddy or turbid waters may also be naturally polluted by soil erosion. For example, color of the water may also be caused by the presence of wastewater of from trace metals leaching into the stream, an industrial effluent outfall may also severely discolor the water because of metals and chemicals. As water color is readily observed, it has a tremendous visual impact that leaves an instant negative feeling. However, green blue water is considered clean, while any brown or reddish brown will be the most easily recognizable pollutant. General clarity of the water is highly valued for two reasons. It makes the immediate statement that this water is not polluted (although this may not necessarily be true) and secondarily allows the viewer to observe bottom flora and fauna.

The water surface is affected by and reflects many natural elements, but it is also the bearer of floating materials which have both negative and positive aesthetic meaning. Floating wood when squared into timbers may well have a negative connotation while a piece of natural tree may well have a positive meaning. Orange peels will be received differently than floating grass. The important factor in the aesthetic acceptance or rejection of these materials is whether it has been associated with human beings. Inorganic substances such as plastic are most evident be their non-organic coloring and

and their oftentimes shiny surface. They are not considered to be aesthetically pleasing. But neither are some organic floating materials such as algal scum, naturally occuring oils, oil, grease, and scum. Suds are especially unpleasant as the late 1950's (pre-biodegradable detergents) settled the foaming rivers image into the minds of many.

The whole range of semi-aquatic plants is considered to be of high visual quality, but their highest quality is observed when they either dominate the water scene or are dominated by it and therefore serve as a textural and color accent. The best floating material is of natural organic origins and is able to provide some color, interest, or excitement (snags) of its own. Also, floating materials with some historical interest, such as an old wooden boat, may be unique enough to of positive aesthetic interest.

An oftentimes forgotten floating material is ice, which with its various structural characteristics (floe, sheet, chunk) can help to impart a strong visual interest to an otherwise mediocre riverscape. It can also have negative aspects, as for instance when the ice is an unnatural color or it has built up on the shoreline enough to destroy vegetation, Generally, it is a positive addition to the riverscape.

The land water interface is graced by vegetation of varying aesthetic qualities. Generally speaking the evergreens,

such as white pine, do not come all the way down to the edge of the water. They may come close enough to the waters edge to be reflected in the water, but they will not break the line of the water's edge. Deciduous trees, such as the willow and the silver maple, can not only live in the moist bank of the river but can also survive spring flood conditions. These trees characteristically hang out over the water thereby, breaking the line of the shore and providing good spot reflections. Although the evergreens may well give good texture and height the deciduous trees provide a great deal of low mass, as well as highlights of trunks bent over the water and branches arching out and dipping into the water. In the more quiet areas of the river the pause in the rush of the river may well be accented by the vertical emphasis of cattails. Associations with many vegetative types is common; pines represent the clear cold maintain stream type; willows and silver maples represent the slow moving peaceful river; cattails represent the calm waters of an old oxbow or feeder pond. All of these vegetation types also are home and refuge to various birds and animals. Riverbanks are probably the best place to listen to the songbirds. Those birds who have a major portion of their diet as fish, such as the seagull and herons, are very active and provide strong visual interest as they go about their feeding. Both their cries and the splashing are excellent additions to the soundscape of the river.

SENSES / RIVER ELEMENTS		FIRST ORDER IMPT			SECOND ORDER IMPT.		
		ASSOC. CONSCIOUS SUB-CONSCIOUS	VISUAL	SMELL	SOUND	TOUCH	TASTE
BIO-CHEMICAL CHAR.	INFECTIOUS AGT.	1 H					2 L
	TOXIC MAT	3 H	4 L	5 H			6 H
	RADIOACTIVITY	7 H				8 L	
	HEAT	9 L	10 H			11 H	
	BIO-STIMULANTS	12 H	13 H	14 H			
	ALGAE	15 H	16 H			17 H	18 L
	BOD & D.O.	19 H	20 L	21 H			22 H
	SUSP. SOLIDS	23 H	24 H	25 L			
	TURBIDITY	26 L	27 H				
	WATER COLOR	28 H	29 H				
	FLOATING MAT.	30 H	31 H			32 H	
NATURAL-PHYSICAL	LAND FAUNA FLORA	33 H	34 H	35 L	36 L	37 L	
	VALLEY WIDTH/HGT	38 H	39 H		40 L		
	RIVER BANK	41 H	42 H	43 L	44 H		
	RIVER FAUNA/FLORA	45 H	46 H	47 L	48 L	49 H	
	RIVER WIDTH TO DEPTH	50 H	51 H		52 L		
	RIVER BED	53 L	54 H	55 L	56 H	57 H	
	FLOW	58 H	59 H	60 L	61 H	62 L	
	ALIGNMENT & EDGE CONFIG.	63 H	64 H				
	EPHEMERAL COND.	65 H	66 H	67 L	68 H		
	VISTAS - IN & OUT	69 H	70 H				
	PHYSICAL ACCESSIBILITY	71 H	72 H	73 H	74 H	75 H	
	DAMS - BRIDGES HIGHWAYS	76 H	77 H		78 H		

(15) = LOCATION OF DISCUSSION
HIGH / LOW = DEGREE OF IMPACT

Although one may not very often see the actual animals that inhibit the shoreline, one sees evidence of them everywhere Beavers have left gnawed trunks, fallen trees, dams, and their houses as evidence of their presence. Perhaps the richest spot to observe evidence of the animals is right along the mud and soft wet sand at the water's edge. Here animal tracks abound, giving notice to their comings and goings. This area holds a keen interest for young and old alike, but it has its greatest impact when it is free of litter and deposits off the surface of the water.

As the river bank is the predominant edge in the riverscape it has great importance, outside of the quality of the water itself it probably has the most importance. It's aesthetic impact is very much a product of its physical make up as to slope, material, and configuration. The ratio of the valley height to width not only helps to determine the slope of the bank but it will also usually be a determinant of shore line configurations. When the topography surrounding the river is composed of steep hills the river will be moving amongst them. It must respond to the larger geographical context. As it curves through them the river banks on the outside of curves will be undercut, making a very steep bank, while the inside of the rivers curves will receive a deposition of materials to form point bars and slope of a much smaller percentage. This same process occurs where the width of the river valley is wide, and the river valley bottom flatter,

but then both slopes are of reduced slope. Over a distance of twenty five feet back from the shore line. To put it in another way, the banksfull stage comes earlier to the flat sections of the river than to the sections where the river is surrounded by steep hills. Usually the material that the bank is made of on the flatter sections of the river valley ranges from coarse gravels to sands. These materials have a lower angle of repose than the materials found in the riverbanks in the steep hills section of the river. The latter section would be made up of glacial fill and/or bedrock which in the case of the glacial fill would have a higher angle of repose than the sand and gravel, and in the case of the bedrock would hold its original status and would respond to the river's action by occasional and dramatic breaking off of large and small chunks spread over long periods of time.

The shoreline configuration will therefore vary very little from the original contours of the land in the steepest sections of the river valley, while in the flatter sections of the river valley it can be expected that the natural degradation and aggradation processes of the river will make a great deal of impact on the easier to move landscape.

When the river valley moves from the steep to the flat and back to the steep very suddenly we can describe the landscape as being varied and having a high visual quality. Not only will we get topographic contrast in the large context

we'll get strong changes in shore line configuration, bank slope, and bank material. We will also note strong interrelationships between different water qualities and the topographic change. Even social change can be observed as the flat sections of the river valley are used for forming and the sections with a steep drop, such as, the site of a falls, were used as a location for an industry seeking water power. At these spots the bank slope, material, and configuration change as 19th Century man built straight vertical granite embankments next to his mill sites. Many of these walls provide a beautiful contrast to the natural riverbank. Unfortuantely, the later trend was to build concrete walls whose uninterrupted monolithic surface is of low aesthetic quality. Even worse is the current practice of dumping a load of fill down the river bank in order to expand a parking lot or other land area. This has an extremely negative impact on the riverscape for it is neither vertical wall nor vegetated slope. It does not even have the qualities of a natural bank cut and consequent slump of bank material. This in itself is not of high aesthetic quality when it occurs naturally but when man does it he creates a convex fill instead of a concave cut which further contributes to the aesthetic negativism of the act by adding unnatural shore line configurations to the already inconsistent materials and slope which do not fit into the immediate surroundings.

The river fauna and flora are extremely dependent on bottom type, mud or sand; the quality of the water; and the flow of the stream. The river fauna and flora have high visual and subconscious values as they are direct indicators of water quality. As the bank fauna and flora have provided numerous opportunities for active and passive recreational activities the same is true of the river fauna and flora. Fishing is the leading sport in the U.S. in terms of number of participants but that does not mean that we should ignore the passive recreator who deserves a great deal of aesthetic enjoyment from watching and hearing a fish break water or following him as he scoots in under the bank. There is a general knowledge of the pollution tolerance levels of many fish, especially the differences between "sport" fish and "trash" fish. Fish, therefore, become a readily recognizable indicator of the pollution level of a water course. As far as flora is concerned, the average person has little understanding of what the various varities indicate about the water quality. Most people lean towards the policy that if the riverbed is mostly free of bottom growing plants, then the river is certainly of good quality. Unfortunately, the response to this must be that "it ain't necessarily so". Plants respond to nutrient levels in the water just as they do on land. If the person is a trout fisherman then he is going to want to see the stream to appear one way, if he is fishing for pike he will expect

a different type of river flora. In river flora and fauna it is generally the fauna that control the aesthetic image of whether the river has a high aesthetic quality for him.

The rivers width to depth relationship has been determined by topography and volume of flora. As such it responds most dramatically to the changing flow of the river, i.e. the amount of water in the river. A narrow river will respond much more dramatically to increased flow and one can observe the whole range of surface conditions due to increased flow characteristics. The broad shallow river will show the effects of increased flow a great deal less, its most dramatic being the covering of exposed mud flats. Because the broad shallow river has a smoother bed it is much less likely to show the large range of surface characteristics than a rocky bottomed river would show, such as standing waves. The wider river may be running just as fast but the indicators of speed are for the most part absent. A noisey boiling river exudes speed. In order to get the sense of speed of the broad river it is necessary to get close enough to observe surface eddies and the loss of clarity. The shallow river has the advantage of allowing the viewer to examine the bottom much more clearly than a deep river. This is, of course, dependent on the clarity of the water as well. Vistas are also extremely important characteristics of the wider river which will usually allow for longer views both into the river area and out of it. The most

exciting qualities of the narrow river are determined by flow and bed characteristics, both of which help in captivating the viewed and bringing him into immediate contact with the riverscape.

The river bed is one of the places that may be immediately noticeable as either a positive or negative river characteristic. If extensive mud flats are seen with decaying plant materials giving off unpleasant odors, or the bottom of the river has sludge deposits or a natural thick mud the aesthetic impact will be a negative one. Mud flats exemplify a river with much less than its average flow, a condition which most people find disagreeable. Contact sports, where contact with the river bed is usual, may be expected to lose some appeal if the river bed is muddy, (sand being the most desirable river bottom material). Colloidal material will fall out in slack water sections of the river, causing locally unpleasant deposits. As well as a sand and gravel bottom a rock bottom is considered to be very exciting visually and is also an extremely important factor in the image of a rushing mountain stream so often used in advertising. When these rocks are separate from the river bed, such as boulders, then they will often have an extremely beautiful sculptered look to them. When river flow covers them there spot will be marked by a standing wave. They are of prime visual and sound producing importance in the aesthetic enjoyment of the riverscape. Rocks mark the rise and fall of the water,

now submerged, now with water rushing about them, and as an exposed piece of sculpture with the river providing the display area. Bedrock as the river bottom material means the highest excitement the river has to offer, waterfalls, cascades, and pools. You can actually stand next to the river or in some cases climb out into the river on exposed bedrock, and immerse yourself in the mists rising from the impact area, every sense pulling in the scene. Fortunately many of these sites are also accessible as they are where mills and towns grow up in order to utilize the water power. The sounds of the fast moving water over rocks is another frequent association made with clean water. This is perhaps best explained by the sounds normal occurance in high mountain areas where clean streams are the norm. However, on the more highly industrialized rivers these flats occur in urban centers where they are more likely to be in poor biological quality. The waterfalls have the ability to aerate the water and thus may serve a dual role of heightening both the aesthetic and the biological quality of the river. It must be remembered the bed composition is only one of two factors necessary to the realization of aesthetic quality that is river flow.

Generally low flow is undesirable because it exposes mud flats and does fit the associations of movement with a river. There is a fear connected with still water, a fear

that it is "stagnant". It is a simple association with still water which can of course be heightened by surface conditions such as algea, or an algal secum. A good flow in the river will cause more interesting surface characteristics that are of high visual quality than will low flow. It means the river is closer to what man associates as its stereotype. Flow can change the alignment and configurations of the edge of a river as well. In a low flow situation the edges are usually not nearly as well defined as for instance at a half banksfull stage. If the river achieves too great a flow, such as flooding its bank, then both river alignment and edge configuration will change radically. This is not to say that a constant water level is aesthetically desirable, for it is a river's strength that it is in a constant state of change. The water level reflects the change in the seasons, and one level provides a foil for the next.

Alignment of the rivercourse assumes aesthetic importance on two levels, from a stationary position looking at it, and traveling along its length, either beside it or on it. From a stationary position the most pleasing river alignment is the one with the most visual contrast but with a well defined alignment. Edge configuration is therefore extremely important in the visual impact of the alignment of the river. A river with straignt alignment but a highly varied edge configuration may have a higher visual quality

than a river with a curvilinear alignment and a straight shoreline. Conversely the alignment with the greatest general aesthetic value would be the curvilinear with a highly varied edge configuration, while the alignment with the least general aesthetic value would be straight with a non-varying edge configuration. Besides curvilinear and straight, and all the intermediary alignments, there is a third one, braided. Because a braided stream is without a well defined edge or channel, it has a very low visual quality.

Alignment very strongly influences the distance which one can see up or down the river from a single viewpoint. Because a straight alignment will necessarily allow the longest views does not mean that it has the most aesthetic quality. What it would gain in distance of view it would lack in mystery and contextual scale. A view should have a fore, middle and background to be of high visual quality and achieve the most aesthetic enjoyment. A curvilinear alignment provides a middleground missing in the straight alignment.

If the viewer is moving along the river the whole complexion of the aesthetic qualities of alignment change. The viewer is now exposed to a sequence of views and the quality of each separate view, the time between the views,

the contrast of consecutive views, and the suspense of the revealing of the land form all contribute to the aesthetic quality of the visual experience of the viewer as he moves along the river basin. If the quality of each separate view is poor but contrasts well with the next consecutive view then the viewer should move along this section of the river faster (speed up the sequence) in order to raise the aesthetic quality of the visual experience. Generally, a natural curve allows the viewer to watch the landscape slowly unfold before him in small parts. As the river's alignment is an example of a natural line it can often contrast very highly with the rigid grid patterns of urbanized areas as it winds through them. The river's alignment, as well as the river valley's configuration, will have a great deal of effect on vegetation because of the river's relation to sun angles and wind. Not only the vegetation but also the surface of the water is effected by the sun and the wind.

Ephemeral effects are these effects of a transitory nature. They are strong contributors to the deep aesthetic associations that people carry with them about riverscapes. Some passive recreators do seek out ephemeral effects as the focus of their recreation. Ephemeral effects consist of the play of the sun on the water: the reflections of the sun which come back to the viewer as bright flashes of

light; the reflections of the sun off the water onto shoreline vegetation, the bank slopes, and the buildings bordering the stream; and the sun throwing the shadows of clouds, vegetation, land masses, and structures onto the surface of the water as well as the riverbed. The more elevated the viewer position the bluer the water will appear as it reflects the blue sky. Clouds as well can be reflected in the water as can vegetation and structures along the bank. The surface quality of the water is altered most dramatically by the effects of wind. Short chop, white caps, cat's paw: even the names of wind effects are dramatic, each inducing a mental picture of a special condition where the mood of the water is changed. Where river current is in opposition to wind direction the effects will be of the most dramatic visual quality. A whole series of ephemeral effects is caused by animals; the tracks by the water's edge, their noises, ripples from fish risers, bugs on the water, a muskrat's passing, and any other manifestations of their presence. Sounds are very important water effects that can make a person feel cool although actually not in contact with the water. One can also hear the presence of water without actually seeing it, a kind of sound accessability to the rivercourse.

Visual accessability to the rivercourse is an extremely strong determinant of aesthetic quality. The viewer

usually sees the river from a dominant (elevated) position and therefore becomes highly conscious of the river as the center-piece of the viewpoint. Prime spots for viewing the river, scenic overlooks, are from highground on either side of the river and from structures associated with the river, such as bridges and dams. If the viewer is unable to see the river his aesthetic experiencing of the river will have to be entirely from past associations with that river or a similar one. Frequently, the vista into a riverbasin is from a highway and the range of aesthetic quality of the viewing experience is due to both the design of the highway and the quality of the river and its surrounding. Land forms at the point of visual interface of the highway and the riverscape. The best highway design responds to the alignment of the river. If the highway orients itself to the better views of the river as well builds up a sequence of views then it will result in an aesthetic experience of a higher order for the viewer. If the viewer is in a wide flat valley the ability to see the river will be sharply curtailed and there will be little visual contrast between the flat river and the flat land. The ability to look down into a steep river valley, where contrast between the flat river and steep slope is great, is of prime visual importance. The views from the river itself are dependent upon topographic variations, alignment and edge configuration and vegetation. The views across the river are determined solely by the width of the river, color,

and massing. By far the most important is the width of the river because if it is narrow then a feeling of a particular space can be felt with visual awareness of detail on the other bank. If the river is wide enough to provide a panorama effect then it is also of high quality. The problem exists in the middle range where details are not seen nor is a panorama established. The view along the river can still be of high quality, however, as it reveals the maze of the landscape. If the banks are above eye level, the river narrow, and topographic variation slight the view from the river may be extremely boring. Otherwise, variation from closure to open spartial situations will be of high aesthetic quality. The open quality of a section of the river (or a lake) can have a positive aesthetic value by being able to concentrate in one place a series of visual resources (long distance views). It can have a negative impact when people have taken advantage of the permanent open quality of a water space to guarantee a view of their advertising signs.

Accessability by physical means is necessary for active aesthetic enjoyment of the river as for boating, fishing, hunting, and nature exploring. Water oriented commercial centers often provide access to the water as well. The secondary impacts of these impacts, such as litter, gas stations, etc. may well outweigh the positive aesthetic qualities of their enjoyment of the recreation. Access can

be used to control the use of a particular area that might otherwise be subjected to overuse. Urbanization in some places has actually achieved this by limiting access to the river such as by chain link fences around power sub-stations or by high walls.

VARIABLE INTERACTION MATRIX

VISUAL IMPLICATIONS FOR THE MERRIMACK RIVER

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DEPENDENT VARIABLES \ EFFECTIVE VARIABLES	WATER QUALITY	WATER QUANITY	LOCATION & DESIGN OF STRUCTURES	LOCATION & DESIGN OF TRANSMISSION LINES	LOCATION OF IRRIGATION AND OVERLAND FLOW SITES
RIVER WIDTH		●			
FLOW DEPTH & MOVEMENT		●	○		
EROSION: SILT EXPOSED MUD	○	●			
EDGE CONTRAST & CONFIGURATION		●	○		○
VISUAL & PHYSICAL ACCESS	○	○	○	●	●
WATER COLOR VISIBILITY-TURBIDITY	●	○			
FLORA GROWTH	●	○			○
FAUNA PRODUCTION & ATTRACTION	●	●			○
FUNCTIONAL USES	●	●	○	○	○

● STRONG INTERACTION

○ SLIGHT INTERACTION

VARIABLE INTERACTION

A general discussion of the water management variables and their interaction with visual variables suggests first that water management programs have effect on approximately 50% of the total visual variables although the major variables are included in those effected.

Water quality can be seen to have the strongest impacts and water quantity, which is controlled to a lesser degree by these management programs, is second in its visual impact.

The location of treatment plants has the least visual impact and the location of the transmission and land disposal facilities have minimal impact upon the river itself.

The visual and physical access and the use functions that the river serves are related to the effective variables of water management systems but do not exert the only control on these dependent variables. Policy and other decisions will have to accompany the management facilities to completely control these dependent variables. For a detailed discussion of the dependent variables see other sections of this report.

AESTHETIC IMPACTS OF ALTERNATIVE WATER MANAGEMENT SYSTEMS ON THE MERRIMACK RIVER

THE WATER SCHEMES

All the water schemes will produce similar visual impacts on the river. Their major consequences will be in their quantity of flow augmentation and the clean quality of the water.

These schemes will maintain the existing river width, and the existing contrast of water to edge materials and slope. They will improve greatly water depth visibility, eliminate water color, and visible mud flats and reduce disconcerting turbidity. The reduction of nutrients will greatly reduce bottom and surface plant growth with reduction in algal growth being the prime example.

The ability to attract greater quantities will be enhanced as will the ability to produce water living species. They will increase the potential for additional functional uses of the river such as recreation and water supply. Visual and physical access will be enhanced only slightly by these schemes by removing the stigma from having contact with the river.

The variations among the water schemes stem primarily from the amount of transport lines that are involved. This trans-

port, since it often involves vegetative clearing near the river has the great potential of increasing the visual and physical access; less transmission reduces this potential. A second variable is the flow characteristics which are altered by having few outfalls or several outfalls along the river. In the wider portions of the river the number of outfalls is not as critical as the quantity of the water. The northern basin would benefit from several outfalls rather than only one.

THE LAND DISPOSAL SCHEME

The land disposal scheme has less effect on the river itself. Its main influence would be upon the planning of land as discussed earlier. It would directly affect the quality of the water by diverting and treating the waste water. It would tend to stabalize the river flow through net surface recharge of the river although the quantities are expected to be reduced.

The attendant impacts of improved water quality identified in the water schemes would also exist for the land disposal scheme.

COMBINATION SCHEMES

The combination schemes tend to maximize the benefits both upon the river and with land planning. They do however

tend to minimize the low flow augmentation potentials except for Combination Scheme 1. However, low flow is possibly less necessary in the wider deep river here than it is in the upper Merrimack. The summer visual appearance may be reduced in some flow dependent variables in the critical high use summer months but the water quality dependent variables would be maintained in these schemes.

Visual and physical access would most likely be enhanced in those areas where it is presently most limited through irrigation and transmission line clearing. The location and design of the treatment facilities in any of the schemes has limited visual impact on the river.

The major visual differences between these schemes is the amount of flow augmentation lost in Scheme 2 by shipping water to Maine and the variation in the number of point sources of augmentation from two to several.

PLANNING AND DESIGN CONSIDERATION

Some planning and design considerations that suggest themselves as being important to the visual impact of the river are

Utilize the rivers for their potential to regenerate urban shoreline development.

Concentrate shoreline development in or near existing

cities and towns and emphasize redevelopment first.

Utilize highway and river intersections, dams, railroad and river intersections, and power transmission lines and river intersections as the points of visual and physical access and recreational and other use developments.

The addition of weirs and aeration jets in key visible points of the river would add visual excitement and interest and make the river a focus.

Develop a conoe-boat-camping system along the river.

Provide all types of physical access inducing facilities adjacent to the river; parks, parking, sanitary facilities, docks, etc.

Design towers, high bridges in the southern portion of the river to give identity to the river's location in the larger landscape and to give the added variety of a viewer dominant position.

Make design and redesign of highways in proximity of the river respond to the river's alignment thus exerting a visible influence on land use.

Utilize the railroad land holdings as access in as many ways as possible.

Integrate STP into existing structured areas rather than adjacent to the river in undeveloped landscapes.

Locate treated water outfalls in deep, fast moving water to minimize visual impression or maximize the outfall by making into a man-made waterfall sculpture in a park-like setting.

The most important issue is to induce use into the river through the facilities provided. This will impart a "use meaning" that will lead to emotional, symbolic and visual meanings as their consequence.

Make use of transmission facilities, and their ability to afford visual access to the river.

Maximize as much as possible low flow augmentation well distributed along the river's length.

Place irrigation facilities both near the river and upon distant hillsides, using the open land created as the greatest contributor to pattern interest.

SUMMARY AND CONCLUSIONS

The Merrimack River is not visually unique at the regional scale and is rather monotonous.

It is an underused visual resource.

The major differences in visual image are between the main stem Merrimack and its Tributaries and between the river and the types of landuse context it passes (agricultural, urban, forest, recreational).

The river is visually polluted for much of its length.

The elimination of open land and lack of visual variety are major problems in the river context.

Contrast, diversity and accessibility are major contributors of resource quality. The river/land edge is the major location for things to happen.

Water quality after treatment and the quantity of total flow are the major variables for visual improvement.

The water schemes have the most direct bearing on the visual quality of the river, while the land disposal schemes most directly affect the land. The combination plans can maximize both types of impact.

Several planning and design implications are readily apparent

and they all revolve around the issue of taking advantage of existing opportunities.

There is sufficient preliminary data generated in the field of aesthetics and operational procedure defined to allow its use in prediction and development of the river aesthetic.

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VISUAL ASPECTS AND IMPLICATIONS OF WASTE WATER MANAGEMENT IN THE MERRIMACK RIVER BASIN.

(a preliminary assessment)

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North Atlantic Corps
of Engineers

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May 27, 1971

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INTRODUCTION

Questions

The proposed extensive controls of waste water in the Merrimack River Basin have promulgated several challenges that should be answered:

- What are the potential visual and cultural use impacts of alternative waste management systems and processes?
- To what extent are these impacts positive or negative?
- What planning and land use potentials and constraints are implicit in the alternative processes?
- What are the existing visual and land use potentials and constraints in the Merrimack landscapes?
- How much physical regionalization of facilities (aside from managerial) is needed to optomize between economic, visual, ecological, social and water quality values?
- Since the scale of waste treatment is likely to increase drastically in the decades ahead, do we benefit visually by adding to the old or by starting with new systems?
- What are the visual and cultural consequences of clean usable water in the Merrimack Basin and the Boston Metropolitan area?

-Can waste treatment facilities be effectively utilized in multi-use combinations with other land uses?

-Visually do we attempt to hide the waste treatment facilities and blend them into the background of the landscape and daily life or make them prominent and physically transparent as a viable, active, necessary part of the community?

-At what point and in what landscapes does long distance transport of waste material begin to visually disturb and disrupt?

-How clean do we want our water to be since it is visually clean long before it is biologically clean?

<u>Definitions</u>

As with the introduction of any issue, it is necessary to narrow the perspective from the universe to something comprehensible. This is particularly true with a topic as broad and intangible as visual impacts (aesthetics), and cultural land use. An extended definition of terms is most often difficult and non productive, but minimal outlines of meaning can serve to guide both the authors and the reader's thoughts.

"Visual impacts" is purposefully chosen expression because it is felt to be somewhat easier to discern if a

physical feature or environment affects you positively or negatively and to some extent how strongly it affects you, (*dramatically, moderately, or insignificantly*). It would be more difficult for instance to agree upon or describe "aesthetics" or "beautiful." The words "visual impact" in this case deal more with the recognition or cognition of the environments and less with their evaluations. Some effort is expended to discern whether the visual impacts are most often negative or positive and how dramatically they are negative or positive. *Cultural uses, for the purposes of this paper,* are simply uses of different land and water areas which have some visual consequence. In this sense they are tied quite directly to visual impacts.

Impact Derivation

As with any land using activity (waste water management facilities) visual and cultural costs and benefits do accrue from the landscape consumed and they are dependent upon two components. *1) the scale and* design quality of the facility and 2) the physical components and quality of the landscape. The more concentrated and developed (structured) the systems (water management processes) the more the design of the facility becomes primary to the visual impact. The simplier,

less technical (land disposal) the process and the more land area consumed, the greater the potential for landscape qualities to be strongly determinant of the resultant visual impact.

Thus planning the location of waste treatment facilities in relation to known landscape qualities produces a positive or negative visual impact. The detailed design decisions of structural mass, height, composition, specific location, materials, although affecting a smaller area, can also have visual costs and benefits depending on the type and scale of the facility. It is obvious that the benefits of both location and design must be maximized.

The waste water management facilities of the future will also become instruments that politically and physically fuse the city and the countryside since both need water and the major sources are the less disturbed landscapes outside the cities. The concern for scale is paramount as expressed in this quote from the Feasibility Study Procedure. "The main thrust will be oriented toward regionalized rather than localized solutions, in order to effect the economics of scale in development.."[1] When thinking of visual impact and cultural land use we automatically think of both large regions and small sites.

The site design concerns of physical plants are very much a part of regional planning concerns of location and use. For clarity in this paper the extremes of this continuum will be stressed avoiding the many intermediate levels of scale. Using the large scale planning-location concerns as one pole and small scale site design concerns as another there are two distinct alternatives available to the designer of waste water management systems, when he considers the visual and land use impacts of his work. He can attempt to minimize the large scale planning decisions (affecting less people) and maximize design considerations of the smaller treatment facilities. This would result in less social conflict and possibly reduced visual and ecological costs, but expanded economic costs. His second clear alternative is to maximize the large scale planning decisions (regionalize the physical treatment facilities and add land disposal) and minimize the many local design decisions. This would facilitate land planning potentials, greater numbers of people being involved in decision making, would serve and educational role, through their involvement, but possibly could result in economic, visual and ecological costs. Obviously both extremes have potential difficulties. A minimum of ecological and visual loss and social

upheaval and a maximum of economic gain would describe an optimal condition that should be established as a goal between these extremes.

General Statements

A way of describing water pollution is to consider it one way of using the landscape. Not until recently with the advent of increased use of complex chemicals has it become apparent that there are some significant secondary costs to such a use. Pollution has thus become an adversary, something that is very necessary in our moralizing self assessing society. It is a common touch stone to aggregate disparate units of our society and thus dealing with water pollution is dealing with people. Water pollution may have some benefits that are yet unexplored. Many of our major cities and much of our countryside has turned its back on the polluted streams, rivers and harbors that were so instrumental in their founding. We thus find enormous stretches of land along the rivers and harbors that are only partially used or not used at all. These most valuable areas of the landscape (land-water edge) should be planned for before clean water again makes them more valuable. Pollution can save some of our valuable landscapes by allowing economically feasible purchase or legal con-

straint to be placed upon such areas before the water quality is improved. This will help mitigate against individual exploitation at public expense.

Clean water can then turn a city around but for public benefit. It can make the water stimulating, exciting and a focus for regrowth and regeneration in the cities and the backbone of our recreational lands in the countryside. To resolve our waste water problems we need not only technology but also legal and economic incentives and penalties. In other words we need planning because clean water as an issue is inextricably woven into the fabric of every day life. Technology alone is incapable of resolving the problems.

Clean water in sufficient quantities is no longer a natural event, it is a public service, and as such it is a "planning tool" of enormous magnitude. Lack of clean water is a primary basis for regional directed growth planning. Giving or withholding the service of clean water combined with legal constraints as to how and where it is used can guide the growth and development of any region.

Once the utilities services, industrial development and transportation are combined in one locale, one has the macro structure for a region's future. With ever

increasing waste discharge standards being implemented across the country, industries will be forced to migrate to water and water cleaning facilities, just as they have migrated to water power, rail transport, the labor pool, and their market in the past. Clean water in abundant quantities, at reasonalbe costs, could be the major attraction to water using industries and thus the stability of a region's future. This country is in need of innovations in public land management policy. Water purification facilities enjoying the economics of scale, could be one of the major tools or incentives to use. In this regard, should the Merrimack wish to insure an industrial future, it should plan not only for present waste quantities but should anticipate far greater quantities and advertise its capacities to provice clean water service at reasonable fixed costs.

Transport costs are one of the major constraints on physical regionalization of dispersed settlements. These transport facilities could be ecologically, visually, and politically costly as well, depending upon the facility (unit train, pipe or tunnel above or below ground). To insure that diseconomies of such transport are not built into future growth, planning to have complete regionalized waste treatment service in some

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areas and not others is mandatory.

Where long distance transport is necessary the common traits of waste transport and human transport should be exploited. Both types of transport occupy the same landscape locale, are generally linear, generally near the rivers, and share the same terminal points. Thus they may find benefit from sharing the same corridors as with the service systems core in contemporary buildings.

There are two general locations of potential water treatment in any water body. Treatment at the point source of "discharge" or the point source of "intake" for use. The first gives the economic burden of a treatment facility for individual industries, towns or small groups of industries, but gives the added advantages of recreationally useful water, a more stable biological environment and potentially a visually pleasing environment. The second scheme gives the economy of scale by making the rivers open conduits for waste products and eliminating the potential recreational, biological and visual benefits. Waste water discharge is not uniformally distributed throughout any river basin and recreational demand, biological disruption and visual access also vary with the environment. Since the quality of waste water discharge and water use vary,

it is most probable that a combination of point source treatment and point use treatment will be facilitated in any one river basin. Thus the end product will be water of varying qualities being discharged into the rivers, at different sections, and varying in relation to the use being made of extracted water. From the visual and cultural point of view it is desirable to maximize point source treatment of waste waters thus aggregating the benefits of clean waters in the environments.

It can be assumed that tertiary water treatment will be needed in vastly expanded quantities in the near future. The economic cost of such treatment will dictate larger scale regional plants as modified by transport costs. The fact that dispersed treatment at point source has larger public benefit than concentrated treatment using rivers as conduits there obviously must be an optimum balance struck between the cost of the dispersed facilities and the visual and ecological consequences of concentrated facilities.

When discussing visual and cultural impacts it is convenient to discuss them as primary and secondary impacts. Just as use of rivers as waste water disposal has secondary costs and benefits the use of clean water

as a planning tool has secondary visual costs and benefits. These secondary impacts may far outweigh the primary impacts of the treatment and transport facilities themselves or the visual attraction derived from clean water. The directed growth of an entire region, the attendant suburbanization or urbanization, and industrial expansion can affect large land areas and be visually more dramatic than the water treatment facilities. For the purposes of this study, secondary visual benefits are assumed to be equal for both types of treatment processes, and potentially more dramatic than the water treatment facilities.

<u>Summary</u>

The guiding criteria to ascertain visual and cultural impacts in the Merrimack Basin can be reduced to the following points:

A. Scale

The amount of area and the population directly affected.

B. Location

Whether the system is responsive to variation and uniqueness in the existing landscapes.

C. Planning Opportunities

The planning opportunities and constraints inherent in the system with particular reference

to multiple use, potential large scale land use control, and becoming active parts of the community.

D. Type of Impact

Whether the impact is generally negative or positive in its visual and land use impacts.

D. Flexibility

The flexibility of the system in terms of location,size, physical composition, and relation to existing waste treatment facilities.

THE EXISTING MERRIMACK BASIN

Major Visual and Cultural attributes

There is a predicted 93% increase in population by the year 2,020 and the amount of developed land is expected to more than double due to increased suburbanization.[2] This will produce extreme pressures on those relatively flat open lands near the river. Without extensive planning and development control the quality of landscape will deteriorate rapidly. Water demands will more than double and quality demands will increase. The population density varies with the northern 1/3 having less than 100 people per sq. mile, themiddle 1/3 from 100-1000 people per square mile and the lower 1/3 from 1000 to 10,000 people per square mile. The population density is in direct correlation to the distance from Boston.

Relative elevations range from less than 100' to approximatley 500' and have no significant bearing upon climate of the Basin. Relative steepness does vary considerably over small areas and thus would represent contraint in waste water management facility locations and their design. There are approximately 220,000 acres in crops and pasture land, the majority of which is adjacent to the river in direct proximity to the population settlements. The Massachusetts portion of the basin and the Concord area contain the largest concentrations of crop and pasture lands.[3]

Approximately 20% of the basin 1000 sq. miles is of a good soil type suitable to land disposal and waste water.[4] This fact suggests that approximately 400,000 acres of marginal farm land are no longer operational. Approximately 5% of the surface area of the basin is water although it is unevenly distributed. Lake Winnipesaukee is the largest lake and Hillsboro, Mierrimack and Windham counties would benefit from the addition of well distributed water bodies.

Forests cover 80% of the N.H. portion of the basin and 60% of the Massachusetts portion. The forest varies with oak hickory dominating in Massachusetts, white and red pine predominating in southern New Hampshire and

maple, beech, birch and hemlock predominating in northern New Hampshire.[5] The oak hickory forests are more tolerant than other forest types, of heavier land use and development, and thus are strategically located for impending development pressures. Connifer forests visually absorb more development because of the year around screening and are striking visual contrasts to the predominate mixed hardwoods of the area. They should be maintained in larger units if possible.

There are approximately 4,000 farms one half of which are less than 100 acres and in marginal use. Agriculture is declining in the basin although the decline is stabalizing somewhat.[6] Pasture and roughage crops were the biggest loss in recent years.

It is predicted that lumber production will go up in the near future, thus much needed open space will again be introduced into the heavily forested setting.

Erosion, excess water and unfavorable soil conditions are the three major constraints upon agriculture in the valley.[7] Erosion and excess water are more easily corrected than qualities of the parent soil material. The future agriculture will be marked by more production from the declining acres.

The southern Merrimack Basin represents the one third of New England with minimal public open space. The White Mountain National Forest in the northern part of the basin protects a major portion of that landscape beyond 2 1/2 hrs. driving time from Boston. When considered with the Boston Metropolitan area, The Merrimack Basin is one of the most intensively developed rivers in New England aside from the Southern Connecticut River.[8] There is much industry and several good highways parallel to the river running generally north and south. The North Atlantic Regional Study, Appendix N., Study of the Visual and Cultural Environment[9] identifies two continuums, (see appendix) in producing visual impacts and influencing land use. They are the land form continuum of Mountains, Steep hills, Rolling hills, Undulating land, Flat land and coast line. Superimposed upon this land form is a land pattern which is generated primarily through a mix of development, forested land and open land, which are then modified by wetlands, water bodies, exposed rock rivers, unique cultural and historic sites and unique vegetation. Taken together the two continuums, relatively stable "land form" and more quickly changing "land Pattern;" can be conveniently used as a way of

describing any visual landscape and its cultural use. (See appendix for more detailed explanation). Once described it can be ascertained what measures are necessary to change or maintain that quality.
A detailed visual study of the neighboring state of Vermont[10] indicates the highest quality landscape pattern is likely to be uniformly distributed throughout the basin while the high quality and unique landscapes are likely to be clustered into contiguous areas. The Merrimack Basin should prove to be less diverse in pattern variety than Vermont due largely to its extensive forest cover, large areas of rolling hills, and large areas of forest town landscape pattern which predominate The visual landscape quality in the northern basin is among the highest possible in the North Atlantic Region and the remainder is of medial quality. Suburbanization accounts for a large portion of the river valley up to and including Manchester and Concord, N.H.[11] The farm forest landscape type and the forest wildland landscape type account for approximately 70% of the basin (1000 sq. miles) and are the closest such landscape patterns to major Metropolitan centers and thus should be protected.

There is a general trend in the northeast toward two types of landscape pattern, a forest town type

in the rural areas and a fringe city suburbanization in the urbanized areas. Both of these landscape pattern types are dominant in the lower Merrimac basin. This is suggesting that the visual landscape is stabalizing at a lower quality. There are several land and water management activities that are needed to maintain and improve the visual quality of the Merrimack Basin landscape. In general they are:[12]

a. develop more heavily in forested lands
b. protect and manage open land
c. improve quality in urban and suburban landscapes through introduction of well distributed water, open land or forests.
d. protect those identified high quality landscapes predominately in the north sub region.
e. improve quality in Rolling Hill Forest Town landscapes through the introduction of water bodies and/or open lands.
f. improve the water quality for the urban dwellers of the region.
g. utilize the river as a structure and as an open space linkage on the regional scale.

These needs to maintain or improve visual quality have some direct connections to waste water management

facilities which will be discussed under each type of disposal. (see appendix for more detailed descriptions of the Merrimack Visual landscape-abstracted from NAR appendix N)

Summary

The major visual and cultural attributes that represent opportunities and constraints upon various waste water management processes and systems are:

a. The pressures and demands by various land uses and waste water management systems are manifest upon the same limited and intensly populated portions of the basin, those lands directly adjacent to the river in the southern basin.

b. Suitable land for land disposal is limited in area and is in dispersed units.

c. Water bodies of high visual quality and recreational utility are needed in several portions of the basin.

d. Forested land dominates this basin and reduces visual quality. Any opportunity to provide well distributed open land in heavily forested areas (except White Mountain National Forest) will improve visual quality.

e. any method to stabalize agriculture as a viable use of open land would develop the secondary benefit of maintaining visual quality.

f. Erosion and excess water management of soils will increase in the years ahead and management for waste water land disposal purposes with nutrient recycling may be a mutually supporting activity.

g. The paucity of public open space in the southern basin may be partially corrected by fee simple purchase of large tracts for land disposal, only part of which may be useful for such disposal. The remaining lands could serve public recreational and open space needs.

h. The intensively developed southern basin is a better example of land areas where regionalization of physical waste treatment facilities could be economically attempted. The rather simple linear river, topography and highway system provide a natural corridor to coordinate transport facilities for the waste.

i. The predominate landscape patterns in the Merrimack are the same predominate varieties in the entire Northeast and are <u>not</u> unique.

Land Disposal Systems

General

The major advantages of land disposal systems are that they can particwally reclaim nutrients, that they offer a planning opportunity to control land use and improve visual quality, and they provide high quality water.

A major planning dilemma in this country, is the blurring of the edges of urbanized areas by suburbanization. This leads to a homogenization of landscape pattern and a reduction of variety, distinctness, identity and visual quality. Through assigning the land a use, such as land disposal of wastewater, one could effectively remove such land from the public market place for public benefit in both economic and visual terms. Such land is not destroyed and land disposal systems are not irreversable, thus land used in this fashion could be used in other ways later, while providing a distinct edge to our urban areas today.

Land disposal for the Merrimack appears to be difficult for several reasons, climate, soil types, soil locations, population densities, etc. The lack of poorly managed soil areas to reconstitute through land disposal

and the requirement to manage the plants, surface condition and sub surface condition of the soil make use of high rate infiltration and spray irrigation economically, visually, ecologically, and institutionally costly. It seems that the economic cost of making large scale land disposal operational in the northeast demands that the land used for disposal as well as the treated water find multiple use for its justification.

The premise that ecological stability and visual quality are based in part on biological diversity in the system and visual diversity in the landscape[13] raises another constraint for large scale land disposal systems. Where economic constraints dictate that large areas of land be simplified and unified in storage logoons, or disposal fields the lack of diversity invites both ecological and visual catastrophe. The major constraints of the Merrimack soils are erosion, excessive water and poor parent materials. Waste water and nutrients will not be helpful in reclaiming much of this type of soil.

The color of the water in land disposal would be brown since water color does not leave until tertiary treatment or after land treatment.

To keep some high investment agriculture viable is essential in the Merrimack. There is potential use

for land disposal for forage crops, and nursery stock, etc. The larger farm fields needed for land disposal are consistent with current agriculture practice but not with visual quality and landscape variation in the basin.

Land disposal in the correct soils could magnify extensively the watershed yield and even provide new managed watersheds that presently have low yields. It is quite obvious by now that the visual impacts of the land disposal systems are much greater than for water disposal systems. This is due mainly to the storage facilities and the change to the land disposal areas. Both land and water waste water management systems are composed of collection, transport, preliminary treatment, and disposal processes.

Water disposal systems have as well secondary and tertiary treatment stages and differ in their disposal technique. Aside from their differences it is assumed that the visual components are the same for both systems. It is further assumed that collection and transport are below ground and are reflected in minor ways through small pump houses, vents and occasional disruption of surface vegetation. Thus the major differences are the

extra treatment facilities and disposal facilities. In the event that large scale tunnels are needed for transport the quantities of rock to be excavated would probably find acceptance in the market and thus would not present a major disposal problem. If the materials were not useful a monumental solid disposal problem would be presented which would significantly alter portions of the Merrimack visual landscape.

Visual Impacts-Flooding Basin

The visual and cultural impacts of the flooding basin or high infiltration technique are the least demanding on land area. Proportionate calculations using LLH sub region as a guide, suggests that approximately 13,000 to 14,000 acres of land would be needed if infiltration was facilitated year around and storage was not required.

The visual impact of this 20 square miles of land would be dramatic since it would entail extensive land grading into level diked cells. These cells must be covered with a protective material such as styrofoam for winter operation thus giving a visual impact similiar in impact and extent to the covered connecticut valley tobacco fields but probably in more concentrated locations. Even if masked by color and texture selection, the

extensive area, manipulation and restriction upon multiple use, make the prospect of these 13,000 acres visually disturbing. It would be disturbing because the character of this open space could not easily reflect the rolling character of the Merrimack landscape.

Steam and local fog would be a potential ephemeral effect from such infiltration beds since they would need to be heated during the winter. This may be visually exciting but could be dangerous to travel and destructive through ice formation on nearby vegetation.

Visual impact of-Irrigation

The irrigation system of land disposal would be demanding for land area and for storage facilities for winter effluent. It has been estimated that 124,000 acres of land area would be needed for a 2" - 3" per week application for a 20 - 30 week period. A storage lagoon of several thousand acres would be necessary or several smaller lagoons. Such lagoons would of necessity be natural land forms that are graded and shaped to the proper depth to control the activity of the waste water.

The introduction of such large water bodies would

normally have a strong positive visual impact on the Merrimack landscape, but the quality of the waste water stored would mitigate against the positive visual impact as would the large scale earth handling.

The irrigation areas would of necessity be clear cut and terraced with extensive underground water management control. Other than irrigation rigs, which would be visually exciting to watch in operation, the managed open land would be negative in its visual impact because of the monotonous vegetation growth and the degree of manipulation of the earth forms.

Visual Impacts-Over land flow

Overland flow is a land disposal system that utilizes approximately the same acerage (124,000 acres) in disposal land and lagoons as the irrigation prodess. Overland flow however utilizes less permeable soils and steeper slopes and requires significantly less soil management. Vegetation in the form of forests could be maintained, and other than irrigation pipes and a series of interceptor trenches the existing visual context would remain the same. This type of system has much less negative visual impact. The visual consequences of the storage lagoons etc. would however remain the same.

This system could support the forest production of the basin or if desired introduce open grassland into forested situations for the visual contrast. It is assumed that none of the land disposal systems would cause fly, rodent or odor problems.

Boston Subregion

In the Boston area especially, large scale storage sites are difficult to find and processes that require large scale land manipulation would be visually accessible to large numbers of people, due to population intensity. Since overland flow requires different soils than are generally available in the area the visual constraints on large scale land disposal systems are severe in this area.

Lowell, Lawrence, Haverhill Sub Region

This area is also quite intensively populated. The soils in this area are more appropriate to irrigation and high rate infiltration. It is probable that smaller scale operations of land disposal could provide open land, maintain some high value agriculture and be visually tolerated in this area. Extensive operations would have to, however, confront the same issues faced in the Boston sub region.

Winnipesaukee Sub region

This region contains both the farm forest and the forest wildland landscapes. The potential of overland flow in limited areas of the forested land and support of agriculture through irrigation in limited areas of the farm forest landscapes is possible. This region offers the greatest potentials to use land disposal on a limited scale of any of the three subregions.

Summary

To summarize land disposal techniques, we can say that they visually affect large land areas and large populations. The systems, other than overland flow, are not responsive to variation in the landscapes and demand large scale land manipulation.

The planning potentials, if coupled with broad legal powers, make land disposal a useful tool. In the right conditions some multiple use of land is possible (forest timber growth, agriculture food crop production, etc.). The impacts of the facilities are generally negative because of their scale and necessity to manipulate the land.

The system is not flexible in terms of location and because of the need for natural storage areas as well as large areas of suitable soil types. The sizes

are fixed through flow quantities. They will, however, accept existing treatment facility wastes.

The scaling up operations would be extremely difficult in or near the Merrimack basin because of the lack of suitable soils.

WATER DISPOSAL SYSTEMS

<u>Visual impacts - physical chemical and biological</u>

The visual impacts of water disposal systems are greatly reduced from those of land disposal due primarily to the reduced land area required for disposal. The activated sludge-biological process followed by physical chemical processes have less acerages in tanks (40% reduction) than the straight physical chemical processes.

Primary treatment through trickling filters, however, as a biological process, ~~are~~ is more conserving of land area. (see appendix for visual-cultural impacts of similar facilities).

The river disposal has several direct visual effects upon the water course where treated effluent, is discharged. First the flow is made more regular during normal low flow periods and thus visually more appealing. Secondly the proposed biological processes

followed by physical chemical processes would purify the water and remove aquatic plants and algae which are not removed by primary biological treatment. Present primary treatment facilities often returns the same oxygen consuming organic matter to the rivers that it is designed to control and thus visually and ecologically destroys its usefullness.

There are several parts to water treatment facilities that are common to both biological and physical chemical processes. Tankage is the main feature of either process and it can occur either inside or outside. Outside tankage is often buried so that only a small portion is visible from a normal viewer position in a car etc. The visual impact is thus reduced. Tankage that is housed in buildings produces larege bulky rather boxy forms that are quite dramatic in their impact on local areas. Approximately 60 acres of tankage would be needed by most of the proposed treatment facilities for all the waste water in the basin including Boston.

There are normally a series of buildings that house various steps and activities in the process. They range in size but are normally quite larege (measured in acres)

and of low profile (greater horizontal distances and low).

Filter beds and storage reservoirs are also attached to many water treatment facilities and are normally open and of geometric form but again of low profile. They are normally clustered in larger groups and these can be visually contrasting to the larger landscape because of their need for level land.

Furnaces and stacks are the only taller vertical elements that are connected with waste water treatment. The stacks themselves would serve as visual focal points to a much larger landscape and also emit visual gases at times, which obviously detract from the visual quality of any landscape.

Mechanical equipment in piping and other forms is becoming a more prevelant in treatment facilities and are normally associated with tertiary treatment, physical chemical processes. These mechanical features if appropriately grouped can add visual excitement and interest to an otherwise dull and blocky treatment facility.

Boston Sub region

The demandsfor land area for either biological

or physical chemical treatment are greatly reduced from those of land disposal and thus could be more easily accomodated in the Boston Region. Existing structures and development would perform the role of a compatable backdrop for the structures of the water treatment facilities.

The visual dominance and contrast of the incineration stacks would provide the greatest degree of constraint upon the location of the facilities. The safety feature of not being down wind of heavy populations would of necessity be considered as well as its visual impact on local buildings, features and landscapes.

The facility is of the scale and character of industrial buildings and could easily become part of industrial districts. Use of the harbor islands for these facilities aside from the physical constraint of limited land area, seems unwise visually. The uniqueness of the islands would be obliterated by such large scale development which demands land manipulation. This is especially true for an incineration stack which is clearly visible by so many people from such a large area. The question of one or several plants makes no significant visual difference except that local disruption would

occur several times rather than a larger local disruption at one point.

Lowell Lawrence Haverhill Subregion

The same issues would probably apply in this subregion. The potential sites would be more restricted if the facilities had to be located on the main stem of the Merrimack River rather than only discharging into the river from other more distant locations.

Winnipesaukee Subregion

This region is more pristine and natural in its visual make up and as a result placement of large treatment facilities would be out of character with the landscape. Location of the facilities in the subregion will need to be carefully done so as not to distract from the recreational value and rich variety offered by this landscape.

Summary

To summarize water disposal techniques affact relatively small areas and are visually equivalent to a large industry. The location of the facilities is critical in urbanized areas and secondly their design to fit them into the existing landscape or to tastefully contrast it.

The planning opportunities offered by clean water are manifest in both treatment procedures but the water treatment does not offer the opportunity for direct land control as with the land treatment procedures. Water treatment will thus rely heavily upon legal and economic means to affect regional planning in any appreciable manner. The impact of these facilities can vary from positive to negative dependent entirely upon the degree of skill with which they are located and designed. Since the scale is small, chances for positive integration are more in control and thus greater. The water treatment systems are flexible in terms of size, expansion, physical composition, and their relation to existing waste treatment facilities. They are reasonably mobile, and thus offer the least visual constraint upon the landscape of the Merrimack Basin.

CONCLUSIONS

It is obvious by this point that it is difficult to talk in detail when exact locations or physical donfigurations of facilities are unknown. It is important to emphasize the idea that in large scale regional approaches the visual impact is most directly affected

by location, and to landscape a facility with flowering shrubs is completely out of this discussion and would be almost ineffective in improving visual quality. Thus this discussion has been appropriately focused to concerns of the regional scale.

The most important visual impacts, other than large scale land disposal would come from the secondary growth and regeneration of existing cities as the result of quantities of clean water.

The question of the optimum of physical regionalization cannot be fully answered by the visual impacts alone. If the transport facilities are underground with minimal surface effect (combined with other transport corridors) the visual constraint of physical aggregation is minimal. This does however, exclude the large scale land disposal systems.

It is a personal feeling that the treatment facilities of the future will be of such a scale and of such large public investment that they can no longer be hidden from the activities of daily life. This is especially true if they are constructed in urbanized areas. An alternative approach is to make them educational features in the landscape, and make as much of the op-

eration visible as possible through both physical and visual access.

The cleanliness of the water does not present an extra strain on the large scale regional landscape because the type and quantity of physical facilities would not drastically increase.

To miss the opportunity of using the "planning tool" of clean water as a major instrument to guide regional growth would be one of the largest losses possible and it would have the greatest secondary visual impacts.

There will have to be a balance struck between large regional scale and small local facilities. The character and desires of the population and their landscape should be used as the guide in striking this balance.

We should gain several types of control over the landscape before we clean the water. This will result in greater public benefit. In visual terms clean water at all points in the river is a greater benefit than centralized treatment and dirty rivers. A balance must be struck here in terms of where and when to treat, and whether to pipe or use the river as a conduit. Visual

quality is maximized by source treatment of waste water.

The Merrimack river is diverse in detail and unified at the macro scale. Any attempt to locate and design treatment facilities as wll as choose the type of facility must take into account these minor variations and unique qualities. There are distinct visual advantages for land disposal in small scale locations, because of the need to visually improve the land pattern.

Soils, forests and climate are the major constraints upon land disposal. Those soils suitable, have the greatest pressure upon them for other non-compatable land uses.

The density of the development in the southern basin makes it feasible for physical regionalization at reasonable costs. The variations in landscape by subregion that have the most bearing upon waste treatment facilities are density of development, quality of the landscape and soil type. Land disposal systems have potential in smaller areas of the basin but produce undue visual pressure when implemented at the macro scale.

Water disposal systems affect mainly small site areas and are subject to design flexibility mitigating the majority of negative visual impacts.

Sludge, brine and incinerator gas provides a major disposal problem from both systems and is best handled through land disposal.

Waste water management facilities have several potential connections to the visual impact at the regional scale:

*They should avoid the White Mountain National Forest, the Lake Winnipesaukee composite quality Recreation area, and the Concord, Massachussetts historic areas.

*They should make high quality water available at all points and in water bodies within the basin.

*They have a potential of protecting and developing open land and agriculture.

*They have a potential to guide regional growth to desired areas through the provision of large quantities of quality water in those areas.

*They have a potential of providing visual and physical barriers to large regions if their transport facilities are not carefully designed.

* They have a potential for clustering growth both through control on distribution of the clean water and the waste water. Clustering as a device offers the maximum advantages to future urban growth.

This preliminary assessment of the visual impact of waste water management facilities has been guided by the type of information available. It has not been responsive in detail to either the landscape subregions or the different treatment processes in part due to the way the material was presented and because the visual differences were minimal at the regional scale.

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9. Coordinating Committee, Appendix N, Visual and Cultural Environmant, North Atlantic Regional Water Resources Study Final Draft, November 1970.

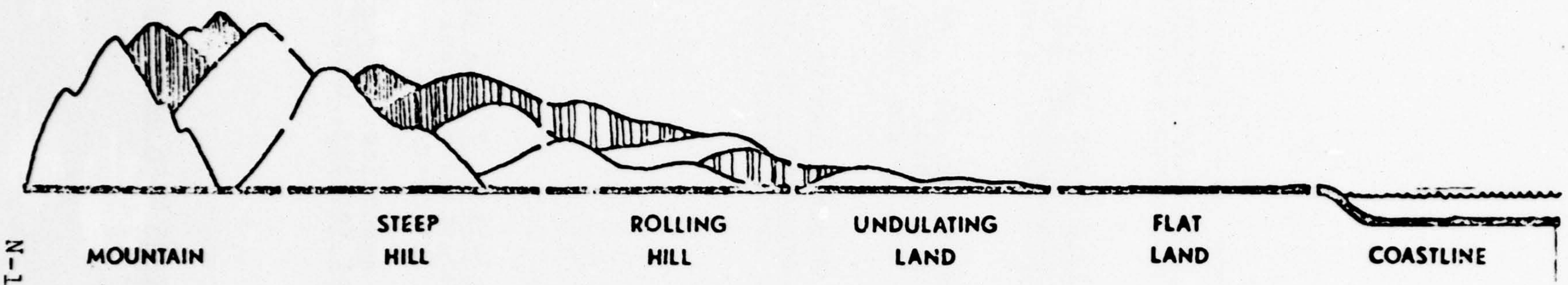
10. Research Planning and Design Assoc Inc., Visual and Cultural Study of the State of Vermont, unpublished draft. May 1971.

11. op cit. 10.

12. op cit. 10.

13. Dasmann, Raymond F. A different kind of country, The Macmillan Co. New York. 1970.

THE LANDSCAPE CONTINUUM



LANDSCAPE SERIES

LANDSCAPE UNITS

BASIN 7

More than half of this basin is composed of Rolling Hills; about one-third is Steep Hills and a lesser amount is Mountains. Most of the area is of a Forest-Town pattern. In addition to the City Units (12%), about 8% of the area is in Forest-Wildland and about 10% in Farm-Forest.

Population density averages 171 persons per square mile (1960 census).

About half of the basin is of first-ranking quality and half is of medial quality. The proximity of the Farm-Forest and Forest-Wildland Units to metropolitan areas should be noted. Lake Winnepesaukee and portions of the White Mountains National Forest are within a 2½ hour driving distance from the Boston metropolitan region. There is a clustering of historic sites in the Concord, Massachusetts vicinity. Needs include the preservation of unique natural landscapes, the protection and development of quality landscapes and the provision of metropolitan amenities and clean water.

An inventory of scientific areas for New Hampshire describing 41 significant sites was published in 1963. It is titled Natural Areas of New Hampshire Suitable for Ecological Research, by Charles Lyon and F. Herbert Bormann and is published by Dartmouth College Department of Biological Sciences.

LANDSCAPE INVENTORY

SERIES	AREA	UNITS	AREA
Mountain	400 sq.mi.	City	600 sq.mi.
Steep Hills	1400 sq.mi.	Farm-Forest	500 sq.mi.
Rolling Hills	3200 sq.mi.	Forest-Town	3500 sq.mi.
		Forest-Wildland	400 sq.mi.

NEEDS, DEVICES AND COSTS - BASIN 7

	Environmental Quality			National Efficiency		
NEEDS	1980	2000	2020	1980	2000	2020
Protect Landscape Quality (sq.mi.)	300	300	300	300	300	300
Develop Landscape Quality (sq.mi.)	70	70	70	35	35	35
Develop Clean Water (% of basin)	75%			75%		
Develop Metropolitan Amenities(sq.mi.)	35			20	15	
LEGAL DEVICES						
Fee Simple (sq.mi.)	255	220	220			
Purchase-Lease Back				55	50	35
Easements (sq.mi.)	150	150	150	150	150	150
Zoning (sq.mi.)				150	150	150
Tax Incentive-Subsidy (sq.mi.)				150	150	150
OTHER DEVICES						
Impoundment	x	x	x	x	x	x
Water Supply	x	x	x	x	x	x
Waste Treatment	x			x		
Recreation Facility	x	x	x	x	x	x
Wildlife Facility	x	x	x	x	x	x
Preventive Flood Plain Management	x	x	x	x	x	x
Watershed Mgmt., Agricultural Practices	x	x	x	x	x	x
Watershed Mgmt., Reforestation	x	x	x	x	x	x
COST IN $ MILLION						
First Cost	58.0	52.0	52.0	28.5	27.5	23.5
Annual Cost				0.3	0.3	0.3
Annual Return				0.3	0.3	0.2

HISTORIC AREAS

SITE AND DATE	LOCATION	AREA	TYPE	CLASS
	Massachusetts			
Whittier (John Greenleaf) House, 1836	Amesbury		BLDG	NHL
Emerson (Ralph Waldo) Home 1835	Concord		BLDG	NHL
Minute Man National Historical Park, 1775	Concord	750 A	SITE	NPS
Old Manse, c. 1765	Concord		BLDG	NHL
Orchard House, mid-19th century	Concord		BLDG	NHL
Walden Pond	Concord	144 A	SITE	NHL
Wright's Tavern, 1747	Concord		BLDG	NHL
	New Hampshire			
Frost (Robert) Homestead 1900-09	Derry vicinity		SITE	NHL
Pierce (Franklin) Homestead, 1804	Hillsboro vicinity		BLDG	NHL
MacDowell Colony, 1907	Peterborough	400 A	SITE & BLDG	NHL
Covered Railroad Bridge				OTH
Daniel Webster Birthplace		150 A		SHM
Hannah Dustin Monument		67 A		SHM

NATURAL AREAS

SITE	LOCATION	AREA	FEATURE	CLASS
Great Meadows National Wildlife Refuge	Mass.	216 A	bio	NFW
Curtiss Dogwood State Scientific Area	N.H.	14 A	bio	SNA
De Pierrefue Sanctuary	N.H.	7 A	bio	AUD
Franconia Notch State Park	N.H.	6635 A	geo	SP
Lost River Reservation	N.H.	50 A	bio, geo	OTH
Rhododendron State Park	N.H.	294 A	bio	SP
Rollins State Park	N.H.	118 A	geo	SP
Sculptured Rocks Wayside Area State Scientific Monument	N.H.	20 A	geo	SNA
Winslow Site State Park	N.H.	2918 A	geo	SP

MERRIMACK RIVER BASIN #7

A

SERIES	QUALITY	AREA SQ. MI.	% OF RIVER BASIN	% OF SERIES IN N.A.R.
M1	H	414	8	3
SH1	H	1422	27	5
RH2	M	2732	51	4
SU4	-	727	14	6
		5295	100	

B.

UNITS	QUALITY	AREA SQ.MI. UNIT QUAL.	AREA SQ.MI. UNIT TYPE	% OF RIVER BASIN	% IN NAR UNIT QUA.	% IN NAR UNIT TYPE	% OF WATER SURFACE
FT	H	1422	3650	27	9.2	9.2	5.5
FT	M	2228		42	10		4
FW	M	414	414	8	1.3	.7	3
FF	H	504	504	9	23	2.1	6
		4568	4568	86			

C

COMBINED QUALITY	AREA SQ. MI.	% OF RIVER BASIN	% OF QUALITY IN NAR
H	2340	44	6.0
M	2228	42	5.7
	4568	86	

D

CULTURAL ATTRIBUTES	NO	SIGNIFICANCE & REMARKS	UNIT LOCATION	AREA
HISTORIC PLACES	3		RH-2a	
STATE PARKS & FORESTS	27		M1a,RH1a,SU4	
NATIONAL " "	1	White Mt. Nat. Park	M-1a	
UNIQUE AREAS				
VEGETATION				
SCIENTIFIC	1			
OTHER				±550 m

MASTER LEGEND

A SERIES

M	MOUNTAIN	X	COMPOUND SERIES
SH	STEEP HILL	C	COASTLINE
RH	ROLLING HILL	SU	SUBURBAN
UL	UNDULATING LAND	U	URBAN
FL	FLAT LAND		

"Number indicates system, Letter indicates unit.

B UNITS

TF	TOWN-FARM
F	FARM
FF	FARM-FOREST
FT	FOREST-TOWN
FW	FOREST-WILDLAND

SYSTEM & UNIT → Ib-FW-H ← RANKING

DESCRIPTIVE LANDSCAPE UNIT

C QUALITY - COMBINED

HIGH MEDIAL LOW

D CULTURAL

HISTORIC SITES

STATE PARKS & FORESTS

NATIONAL PARKS & FORESTS

LARGE NATIONAL AND STATE FORESTS & PARKS

POPULATION DENSITY - LESS THAN 50 PEOPLE/SQ.MI.

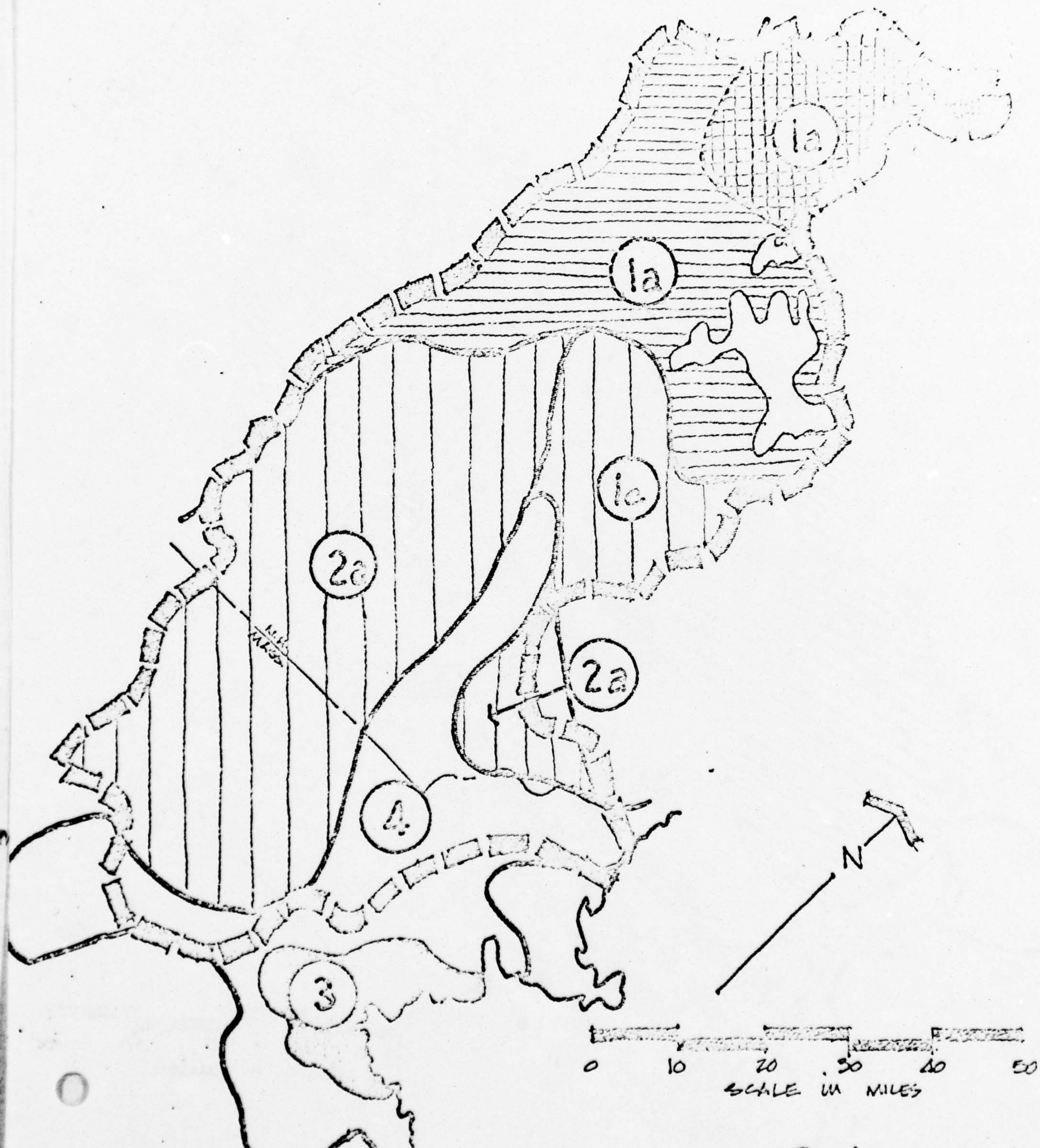
50/500 PEOPLE/SQ.MI.

MORE THAN 500 PEOPLE/SQ.MI.

DRIVING TIMES 1 or 2½ HOURS

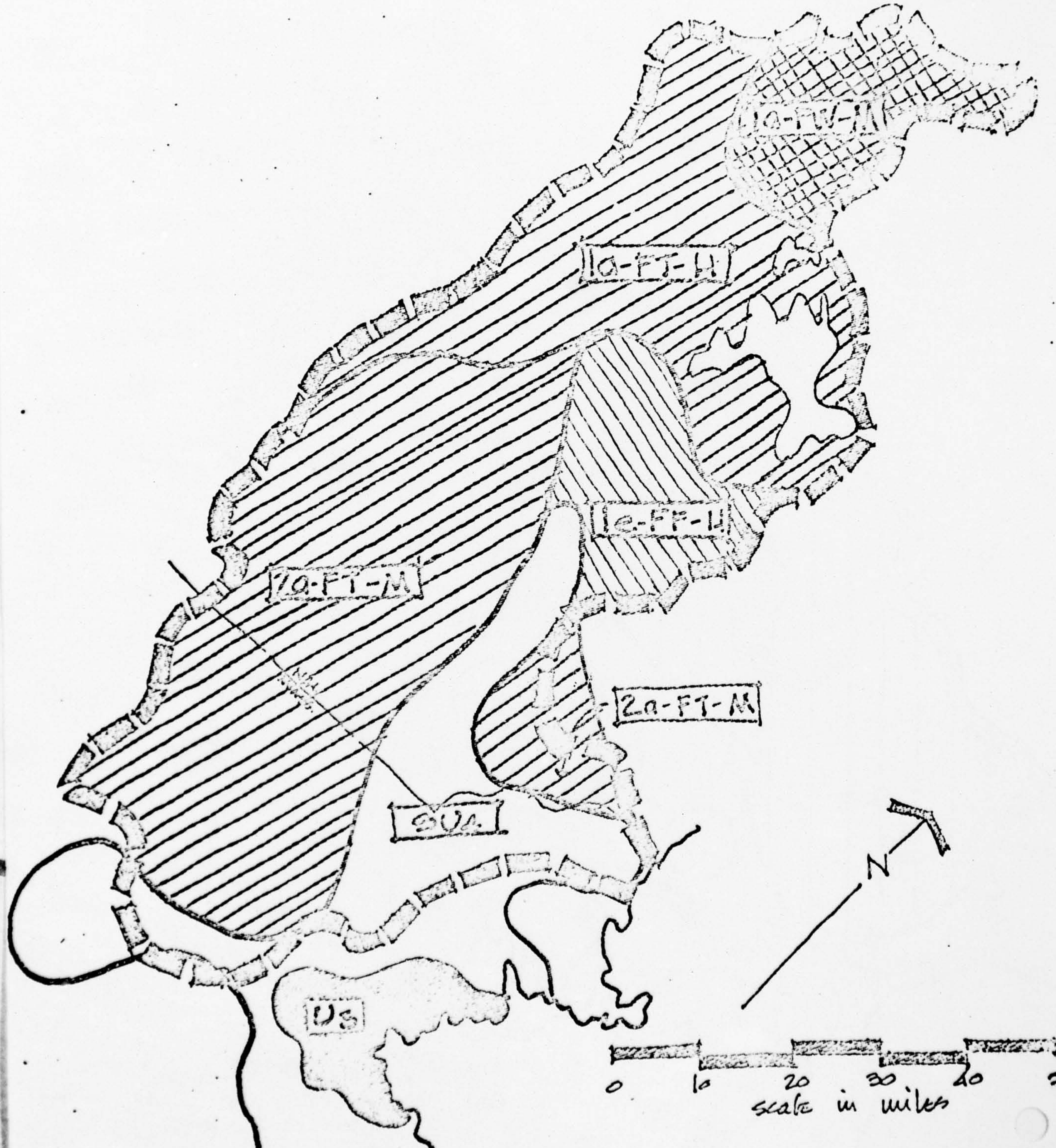
UNIQUE AREAS: VEGETATION SCIENTIFIC

MERRIMACK RIVER #1



Series A

MERRIMACK RIVER 7

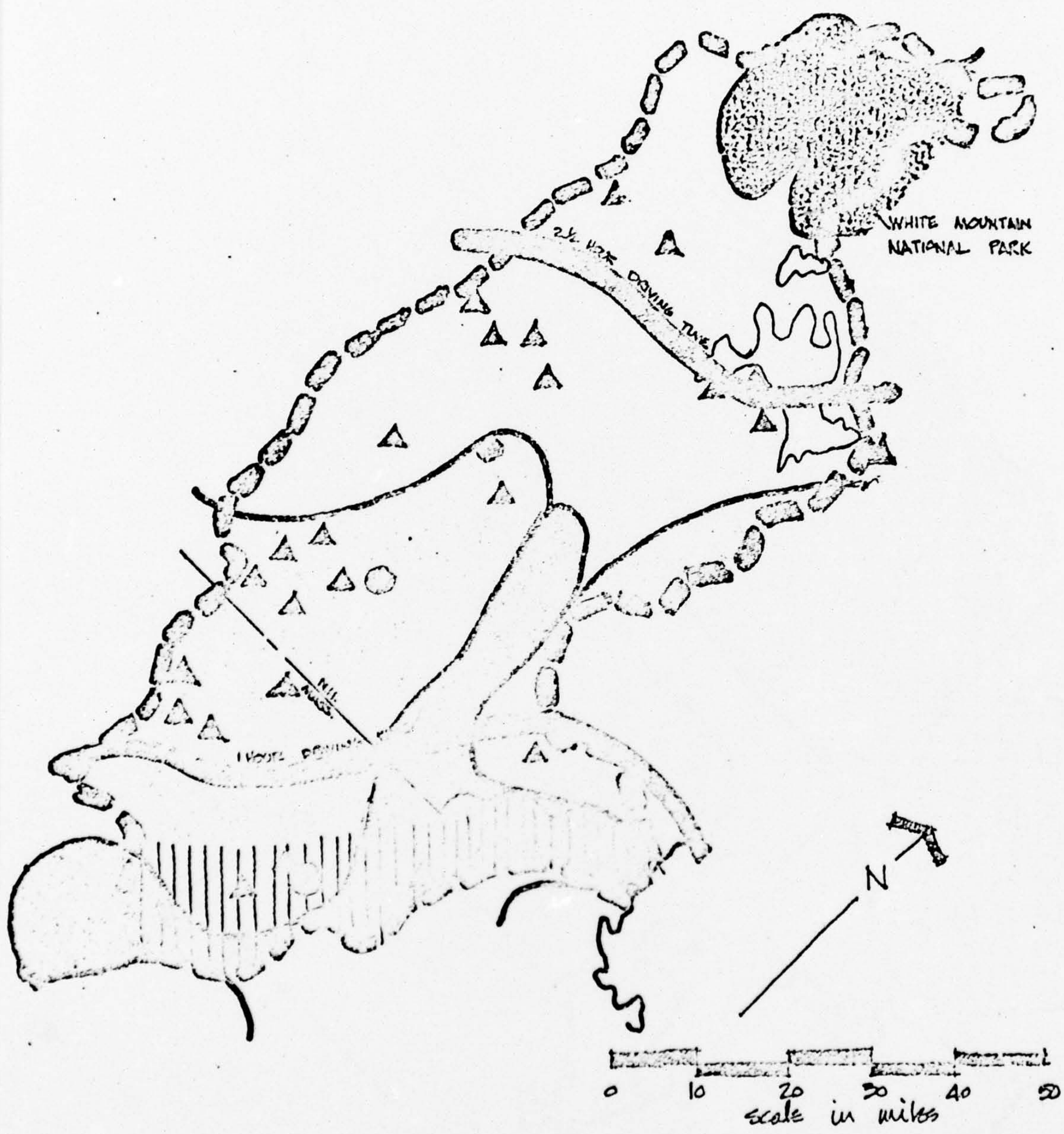


Units B

MERRIMACK RIVER 7

Quality C

MERRIMACK RIVER #7



Cultural D

TABLE N-12

POTENTIAL VISUAL IMPACT OF WATER MANAGEMENT DEVICES ON LANDSCAPE SERIES

PHYSICAL DEVICES	M	SH	RH	UL	FL	C	X
Filling and Excavation	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	Lp-Ln
Clearing & Cleaning	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	Lp-Ln
Bank Protection	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	Lp-Ln
Diversion	NNA	NNA	NNA	O-Hn	O-Hn	NNA	O-Hn
Dikes, Levees, Flood Walls	NNA	NNA	Ln-Hn	Ln-Hn	Ln-Hn	NNA	Ln-Hn
Sea Walls, Breakwaters, Sea Levees, etc.	NNA	NNA	NNA	NNA	NNA	Lp-Hn	NNA
Sand Fill-Beach Stabilization	NNA	NNA	NNA	NNA	NNA	Hp-Lp	NNA
Power Generating Installation	O-Ln	O-Ln	Ln	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn
Waste Treatment & Water Renovation Inst.	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	NNA
Desalination Installation	NNA	NNA	NNA	NNA	NNA	O-Ln	NNA
Off Stream Cooling Installation	O-Hn	O-Hn	O-Hn	O-Hn	O-Hn	Ln-Hn	Ln-Hn
Dams & Hydroelectric Power Installations	Lp-Ln	Lp-Ln	O-Ln	O-Hn	Ln-Hn	Ln-Hn	Lp-Ln
Recreation Facility	Lp-O	Lp-O	Lp-O	Lp-O	Lp-O	Hp-Ln	Lp-O
Fish & Wildlife Fac.	Lp-O	Lp-O	Hp-O	Hp-O	Hp-O	Hp	Hp-O
Water Supply Facility	Lp-O	Lp-O	O-Ln	O-Ln	O-Ln	O-Ln	Lp-O
Ground Water Management Facility	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln
Drainage Facility	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	NNA
Navigation Facility	NNA	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA
Waste Disposal Fac.	NNA	NNA	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn
Impoundments	Hp-Lp	Hp-Lp	Hp-Lp	Hp-Lp	Hp-Lp	NNA	Hp-Lp
PHYSICAL/NON-PHYSICAL DEVICES							
Flood Plain Mgmt.	NNA	NNA	NNA	Hp-Hn	Hp-Hn	Hp-Hn	Hp-Hn
Watershed Mgmt.	Hp-O	Hp-O	Hp-O	Hp-O	NNA	NNA	Hp-O
Preservation	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O

LEGEND

NNA	Not normally applicable	M	Mountains
Hp	Moderate to high positive visual impact	SH	Steep Hills
Lp	Low to moderate positive visual impact	RH	Rolling Hills
O	No significant change in visual impact	UL	Undulating Land
Ln	Low to moderate negative visual impact	FL	Flat Land
Hn	Moderate to high negative visual impact	C	Coastline
		X	Compound

TABLE N-13

POTENTIAL VISUAL IMPACT OF WATER MANAGEMENT DEVICES ON LANDSCAPE UNITS

PHYSICAL DEVICES	CC	IC	FC	TFa	Fa	FaFo	FoT	FoW
Filling and excavation	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln
Clearing & Cleaning	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln
Bank Protection	Lp-Hn	Lp-Hn	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln
Diversion	Lp-Hn	Lp-Hn	Lp-Hn	O-Hn	O-Hn	O-Hn	O-Hn	O-Hn
Dikes, Levees, Flood Walls	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn
Sea Walls, Breakwaters, Sea Levees, etc.	NNA	Lp-Ln	Lp-Ln	NNA	NNA	NNA	NNA	NNA
Sand Fill-Beach Stabilization	NNA	Hp-Lp	Hp-Lp	NNA	NNA	NNA	NNA	NNA
Power Generating Installation	Ln-Hn	Ln-Hn	Ln-Hn	O-Hn	Ln-Hn	Ln-Hn	Ln-Hn	O-Hn
Waste Treatment & Water Renovation Ins.	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	NNA	NNA	NNA
Desalination Installation	NNA	Lp-Ln	O-Ln	NNA	NNA	NNA	NNA	NNA
Off Stream Cooling Installation	Ln-Hn	Ln-Hn	Ln-Hn	O-Hn	O-Hn	O-Hn	O-Hn	O-Hn
Dams & Hydroelectric Power Installation	NNA	NNA	O-Hn	Lp-Hn	O-Hn	Lp-Hn	Lp-Hn	Lp-Hn
Recreation Facility	Hp-Lp	Hp-Lp	Lp-O	Lp-O	Lp-O	Lp-O	Lp-O	Lp-O
Fish & Wildlife Fac.	NNA	NNA	NNA	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O
Water Supply Fac.	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	O-Ln	O-Ln	O-Ln	Lp-Ln
Ground Water Management Facility	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln
Drainage Facility	NNA	NNA	NNA	Lp-Ln	Lp-Ln	Lp-Ln	NNA	NNA
Navigation Facility	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	Lp-Ln	NNA
Waste Disposal Fac.	Ln-Hn	Ln-Hn	Ln-Hn	Ln-Hn	NNA	NNA	Ln-Hn	NNA
Impoundments	NNA	NNA	Hp-Lp	Hp-Lp	Hp-Lp	Hp-Lp	Hp-Lp	Hp-Lp
PHYSICAL NON-PHYSICAL DEVICES								
Flood Plain Mgmt.	Hp-Hn	Hp-Hn	Hp-Hn	Hp-Ln	Hp-Hn	Hp-Hn	Hp-Hn	Hp-Hn
Watershed Mgmt.	NNA	NNA	NNA	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O
Preservation	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O	Hp-O

LEGEND

NNA	Not normally applicable	CC	Center City
Hp	Moderate to high positive visual impact	IC	Intermediate City
Lp	Low to moderate positive visual impact	FC	Fringe City
O	No significant change in visual impact	TFa	Town-Farm
Ln	Low to moderate negative visual impact	Fa	Farm
Hn	Moderate to high negative visual impact	FaFo	Farm-Forest
		FoT	Forest-Town
		FoW	Forest-Wildland

TABLE N - 14

POTENTIAL CULTURAL IMPACT OF WATER MANAGEMENT DEVICES ON LANDSCAPE SERIES

PHYSICAL DEVICES	M	SH	RH	UL	FL	C	X
Filling and excavation	NNA	NNA	Li-O	Li-O	Li-C	NNA	Li-O
Clearing & Cleaning	NNA	NNA	Li-O	Li-O	Li-C	NNA	Li-O
Bank Protection	NNA	NNA	Li-O	Li-O	Li-C	NNA	Li-O
Diversion	NNA	NNA	NNA	Li-O	Li-C	NNA	NNA
Dikes, Levees, Flood Walls	NNA	NNA	O-Ld	O-Ld	O-Ld	NNA	O-Ld
Sea Walls, Breakwaters, Sea Levees, etc.	NNA	NNA	NNA	NNA	NNA	Li-Hd	NNA
Sand Fill-Beach Stabilization	NNA	NNA	NNA	NNA	NNA	Hi-Li	NNA
Power Generating Installation	O	O	O	O-Ld	O-Ld	Ld	O-Ld
Waste Treatment and Water Renovation Inst.	NNA	NNA	Li-O	Li-O	Li-O	NNA	Li-O
Desalination Inst.	NNA	NNA	NNA	NNA	NNA	O-Hd	NNA
Off Stream Cooling Installation	O	O	O	O-Ld	O-Ld	Ld	O-Ld
Dams & Hydroelectric Power Installations	Li-O	Li-O	Li-O	Li-Ld	Li-Ld	Li-Hd	Li-O
Recreation Facility	Li	Hi	Hi	Hi	Li	Hi	Hi
Fish & Wildlife Fac.	Li	Li	Li	Li	Li	Li	Li
Water Supply Facility	O	O	Li	Li	Li	Li	Li
Ground Water Management Facility	NNA	NNA	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld
Drainage Facility	NNA	NNA	Li-O	Li-Ld	Li-Ld	Li-O	NNA
Navigation Facility	NNA	NNA	NNA	Li-Ld	Li-Ld	Li-Ld	NNA
Waste Disposal Fac.	NNA	NNA	Ld-Hd	Ld-Hd	Ld-Hd	Ld-Hd	Ld-Hd
Impoundments	Hi-Li	Hi-Li	Hi-Li	Hi-Li	Li	NNA	Hi-Li
PHYSICAL NON-PHYSICAL DEVICES							
Flood Plain Mgmt.	NNA	NNA	NNA	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd
Watershed Mgmt.	Hi-Li	Hi-Li	Hi-Li	Hi-Li	NNA	NNA	Hi-Li
Preservation	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld

LEGEND

NNA	Not normally applicable	M	Mountains
Hi	Opportunity for moderate to high increase in use	SH	Steep Hills
Li	Opportunity for low to moderate increase in use	RH	Rolling Hills
O	No significant change in use	UL	Undulating Land
Ld	Low to moderate decrease in use opportunities	FL	Flat Land
Hd	Moderate to high decrease in use opportunities	C	Coastline
		X	Compound

TABLE N - 15

POTENTIAL CULTURAL IMPACT OF WATER MANAGEMENT DEVICES ON LANDSCAPE UNITS

PHYSICAL DEVICES	CC	IC	FC	TFa	Fa	FaFo	FoT	FoW
Filling and Excavation	Hi-O	Hi-O	Hi-O	Li-O	Li-O	Li-O	Li-O	Li-O
Clearing & Cleaning	Hi-O	Hi-O	Hi-O	Li-O	Li-O	Li-O	Li-O	Li-O
Bank Protection	Hi-O	Hi-O	Hi-O	Li-O	Li-O	Li-O	Li-O	Li-O
Diversion	Hi-O	Hi-O	Hi-O	Li-O	Li-O	Li-O	Li-O	NNA
Dikes, Levees, Flood Walls	Hi-Hd	Hi-Hd	Li-Hd	O-Ld	O-Ld	O-Ld	O-Ld	O-Ld
Sea Walls, Breakwaters, Sea Levees, etc.	NNA	Li-Hd	Li-Hd	NNA	NNA	NNA	NNA	NNA
Sand Fill-Beach Stabilization	NNA	Hi-Li	Hi-Li	NNA	NNA	NNA	NNA	NNA
Power Generating Installation	O-Hd	O-Hd	O-Hd	O-Ld	O-Ld	O-Ld	O-Ld	O-Ld
Waste Treatment and Water Renovation Ins.	NNA	Hi-O	Hi-O	Li-O	NNA	NNA	NNA	NNA
Desalination Instal.	NNA	Hi-Li	Hi-Li	NNA	NNA	NNA	NNA	NNA
Off Stream Cooling Installation	O-Hd	O-Hd	O-Hd	O-Ld	O-Ld	O-Ld	O-Ld	O-Ld
Dams & Hydroelectric Power Installations	NNA	NNA	Hi-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-O
Recreation Facility	Hi	Hi	Hi	Hi-Li	Hi-Li	Hi-Li	Hi-Li	Hi-Li
Fish & Wildlife Fac.	NNA	NNA	NNA	Li	Li	Li	Li	Li
Water Supply Fac.	Hi	Hi	Hi	Li-O	Li	Li-O	Li-O	Li-O
Ground Water Management Facility	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld
Drainage Facility	NNA	NNA	NNA	Li-Ld	Li-Ld	Li-Ld	NNA	NNA
Navigation Facility	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	Li-Ld	NNA
Waste Disposal Facil.	Ld-Hd	Ld-Hd	Ld-Hd	Ld-Hd	NNA	NNA	Ld-Hd	NNA
Impoundments	NNA	NNA	Hi-Li	Hi-Li	Hi-Li	Hi-Li	Hi-Li	Hi-Li
PHYSICAL/NON-PHYSICAL DEVICES								
Flood Plain Mgmt.	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd	Hi-Hd
Watershed Mgmt.	NNA	NNA	NNA	Hi-Li	Hi-Li	Hi-Li	Hi-Li	Hi-Li
Preservation	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld	Hi-Ld

LEGEND

NNA	Not normally applicable	CC	Center City
Hi	Opportunity for moderate to high increase in use	IC	Intermediate City
Li	Opportunity for low to moderate increase in use	FC	Fringe City
O	No significant change in use	TFa	Town-Farm
Ld	Low to moderate decrease in use opportunities	Fa	Farm
Hd	Moderate to high decrease in use opportunities	FaFo	Farm-Forest
		FoT	Forest-Town
		FoW	Forest-Wildland

CATEGORY C: BUILDINGS AND OTHER LARGE STRUCTURES

This category includes free-standing buildings and related large structures and/or complexes related to water use or water processing such as: power generating plants including conventional thermal, pumped storage and nuclear plants, waste treatment-water renovation plants, desalination plants and off-stream cooling plants. The structures are large and dominant in relation to the individual and to the surrounding landscape. They present a complex visual image composed of many parts. A relatively flat site for major construction is required and this is normally near or at the edge of a water body.

Power Generating Installation: This device consists of brick, concrete or metal buildings and structures with power line connections, waterfront connections, fuel storage areas, tall smoke stacks, generators and other elements which comprise a power generating unit. Size, complexity and location are key elements in the

determination of its impact upon the landscape. Conventional thermal, pumped storage and nuclear plants are discussed collectively in this section. Individual differences are pointed out where necessary. These devices are used in most Series and Units but are not frequently found in Mountain Series in the NAR.

Visual Impact

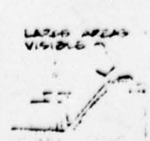
The plant can be seen from great distances because it is usually located on flat landscapes and adjacent to an unobstructed open space (water body).

Power plants are visually acceptable from distances of a mile or more by acting as a counterpoint or accent to large areas of natural or man-made landscape. Because of its size, dominance and complexity, the plant can create visual interest and excitement when the viewer is in close contact and all, or most of the view is directed at the structure itself. Power plants are most detrimental to visual quality when viewed from the middle distance. At this distance natural land forms are seen in strong contrast to the structures and their frequently attendant clutter.

These installations can be detrimental to visual quality when they disrupt the continuity of a shoreline, emit air and water pollutants and are designed and constructed without regard for the relationship of the structure to its surroundings. Detrimental aspects can be minimized by orienting the total structural complex so as to occupy as little waterfront as possible.

They are frequently constructed away from dense concentrations of people and therefore are seen in strong contrast to natural forms and materials.

Nuclear plants, although large, have a more unified and less distracting visual impression than fossil fuel plants because of a generally simpler structure and because of the elimination of major fuel supply yards.



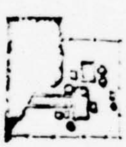
Pumped storage plants visually affect larger areas than other power plants because of their necessary location adjacent to hillsides, the need for

high elevation reservoir storage and the resultant scarring of the hillsides.

Power lines detract from the landscape when they appear as the only structural element in large open areas and when they have no formal relation to existing landforms. The detrimental aspects can be reduced by relating power line alignment to the land form rather than to arbitrary straight lines across rolling and curving landscapes.

Smoke stacks are normally elements of strong contrast when located in open areas and can serve as points of identity and reference. They are not visually detrimental by themselves except when in conflicting relationship to other vertical structures or producing air polluting emissions.

Cultural Impact



Power plants often limit the use of large portions of waterfront. They also may limit the use of the water body through such practices as the discharge of pollutants.

Power plants often affect land values and the use potential for large areas of the land within view of the plant.

Ecological Impact

The most significant proven impact of thermal power plants is from thermal pollution. Raising average water temperatures has a general effect of accelerating eutrophication. The most predictable changes are a reduction of oxygen levels and a more rapid release of mineral nutrients. This results in a loss of fish and other animal life, and the promotion of rapid plant growth. If the temperature change is great, a loss of most plant and animal life may occur.

Changes in water temperature may produce local micro-climatic disturbance in the form of increased fog, higher humidity and the extension of frost-free dates during both the spring and fall.

Pumped storage plants greatly influence flow pattern on a daily basis.

Surges in stream flow during hours of power generation may produce continuous channel erosion downstream from the outfall.

Daily periods of increased flow may disturb bottom flora and fauna and reduce productivity of the aquatic environment.

Depending on the design of the intake, it may cause direct destruction of fish life.

Waste Treatment - Water Renovation Installation: Waste treatment complexes are composed of buildings, holding, aeration and settling tanks, filter beds, chemical supply and other structures. They are

generally smaller in size than power generating plants and require land areas of one to several acres. The most outstanding features are the water treatment basins or tanks and the building itself. Size, location and design are key elements in the determination of visual, cultural and ecological impact. This device is most often used in the Intermediate City, Fringe City, and the Town-Farm Units.

Visual Impact

The visual impact is typical of many smaller industrial or commercial buildings - rectangular in form with a simple horizontal, low silhouette -visually affecting a relatively small area.

Architectural design quality and plant location are both important elements in determining the visual impression.

Water storage bodies and aeration jets can contribute in a positive way to the general visual impact.

Cultural Impact

The facility can provide the impetus for additional community growth by the provision of increased water supply for industrial or other growth needs.

Increased quantity and quality of the water encourages other uses such as swimming or irrigation.

Ecological Impact

General water quality can be improved through the removal of suspended solids and toxic materials. Greater sunlight penetration will result which promotes plant growth and creates a more productive food base for the entire aquatic community. Removal of solid organic materials will reduce the oxygen demand made by the bacteria of decay. Dissolved oxygen levels favorable to aquatic plants and animals will be maintained.

Large amounts of nutrients (nitrogen and phosphorus) may be introduced through the discharge of treated effluent. Higher nutrient content in the water may promote rapid plant growth. If this occurs at rates in excess of the rate of organic breakdown of dead material, then an oxygen deficiency may result. If take up and recycling of nutrients is accelerated, eutrophication may result.

Desalination Installation: This device for the extraction of salts and other materials from sea water is composed of buildings, fuel storage facilities, exhaust stacks, water connections, reservoirs and machinery and equipment complexes.

The buildings are normally small and not a dominant part of the complex. However, much of the processing equipment is exposed. There are many types and forms of plants in experimental stages and flexible sites are required for anticipated increases in size or form. Presently they are being used only where serious water shortages exist. This device is most often used in Coastline Series.

Visual Impact

The plant complex is often composed of repetitious units which are more complex, mechanical and scientific looking than other water use or processing devices and are more interesting to view.

The plant can be seen from great distances because it is usually located on flat landscapes and adjacent to an unobstructed open space (water body).

These installations can be detrimental to visual quality when they disrupt the continuity of a shoreline, emit air and water pollutants and are designed and constructed without regard for the relationship of the structure to its surroundings. Detrimental aspects can be minimized by orienting the total structural complex so as to occupy as little waterfront as possible.

Cultural Impact

A desalination operation can control or extensively limit future development within an area deficient in water resources by witholding or controlling the amount of usable water provided.

The plant can consume large portions of level land along the coast.

Ecological Impact

Ecological impact could be severe but conditions vary so much from site to site that generalizations cannot be made.

Ground Water Management Facility: Ground water management is defined as the controlled modification of the hydrologic cycle by artificial means or actions to achieve some desirable water use benefit. It is concerned with both surface and subsurface water. It is used in river basins for flood control, water supply, water quality control, flow augmentation, ground water recharge and return, maintenance of ground water level, prevention of salt water encroachment and salinity control. Ground water management devices include drilled wells, pit lagoons, spreading basins, canals, gallery collection and ground water lakes. They are most effective when used in combination. In this way they are better able to meet changing water conditions.

Ground water management involves large areas which often overlap political boundaries, even several Landscape Series and Units. The three types of aquifiers; coastal plain, glacial drift and consolidated rock are in different locations within the NAR and require different types of devices to accomplish their management purposes.

Visual Impact

The visual impact of ground water management is

minimal unless ground water lakes are created or water flow is materially changed.

Ground water lakes develop strong contrast with their surroundings and add to the visual interest and quality of a particular landscape.

Flow augmentation could enhance both the quality of the water and the interest it creates during the summer months when many people can enjoy it.

Recharge wells are effectively used in the headwaters of major NAR rivers. They are very small and require minimal amounts of land. Their visual impact is minimal except for access roads and minor buildings.

Gallery collections and pit lagoons normally cause alteration of existing land forms and are occasionally obvious distractions.

Cultural Impact

Ground water management can dispose of storm water or treated effluent without causing flood damage from stream discharge.

Ground water lakes add to the land value and to the intensity of use of the land surrounding them.

Domestic sewage tank disposal has long served as an effective means of ground water recharge and as a disposal function at the same time.

Odors from large area effluent recharge can become obnoxious in densely populated areas where they are most used and needed and can reduce value and limit use of the surrounding land.

Ground water management for aquifiers near the surface could influence land use patterns by placing restrictions on the type and design of the uses over these aquifiers.

Ecological Impact

Where ground water lakes are created, entire new ecosystems are introduced in the water and in the adjacent land. The new water table materially affects the wildlife carrying capacity of an area.

Ground water management that encourages development of old age water conditions may reduce water quality drastically and alter the ecosystem of that area.

Drainage Facility: The following covers the impacts of drainage upon agricultural and related land uses. Drainage is defined as the removal of excess water by artificial means or, as the retarding or slowing down of rapid surface drainage to prevent erosion. Pipes, granular materials, ditches, sodding and other ground covers, tree planting, outlet pipes and other small structures are physical techniques used to accomplish the task.

Over half of the nation's surface contains excess water which prevents productive agriculture and related land uses. Drainage problems occur sporadically throughout all of the Landscape Series and Units of the NAR and affect large areas as well as small. Drainage is used in conjunction with almost every type of land use. It can be accomplished by surface or subsurface means.

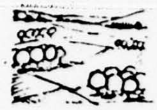
Drainage most often involves the minipulation of natural materials and forms. The character of the area involved, the severity of the drainage problem and the regenerative capacity of the landscape all control the ultimate visual, cultural and ecological impact. The visual and cultural effects are more the result of the intensified or altered use of the areas improved by drainage than of the drainage devices themselves.

Visual Impact

Drainage allows intensive agriculture and other types of land use which generally increase landscape diversity or interject new elements into landscape pattern. If agriculture is already present, it may decrease landscape diversity by the loss of wetlands in exchange for more farmland.

The addition of a drainage facility does not add significant visual contrast to the landscape; it tends to blend with the landscape because of the predominant use of natural materials.

Drainage will change the type of plant material a particular piece of land can support.



The surface ditches often encourage adjacent vegetative growth which, in combination with the ditch, create dividers and enhance pattern in the landscape. Crop variety in the adjacent fields can often strongly emphasize these dividers. The total result is increased visual variety.

Drainage that prevents erosion problems is an automatic step to increased visual value.

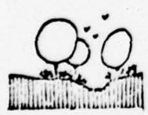
Drainage often results in permanent ponding in low points adjacent to the drained land. These ponds serve as focal points.

Subsurface drainage normally causes minimal visual changes to the landscape except where major areas of vegetation are removed.

Paved drainage ditches in heavy run-off areas can be a strong visual contrast, and a "misfit" in a natural setting.

Drainage often requires minor and occasionally major change to the earth form and slope. The more dramatic this change the more distraction is created.

Cultural Impact



Drainage ponds offer potential for recreational use.

Surface drainage ditches often add habitat for fish and wildlife, increasing the possibilities for hunting, fishing and nature study. The "edge effect" along surface drains is often excellent game bird habitat.

The drainage of land facilitates circulation and access to that land.

Drainage represents an improvement and an investment in the land that requires the new use to yield a higher return. The withholding or implementing of drainage facilities can serve as an important control on land use.

Ecological Impact

Ecological impact, both terrestrial and aquatic, is

determined not as much by the drainage method used as by the areal extent of land involved and the amount of water displaced.

In the NAR the ecological impact of drainage is strong because it affects large areas.

Whenever excess water is removed from one area and deposited in another the terrestrial and aquatic conditions of both areas change. Normally the change exists only as long as the drainage facility is active and natural conditions return after an intervening time period.

Navigation Facility: This discussion considers navigation on inland waterways and includes commercial navigation but not recreational boating. It is concerned with navigation facilities placed on a water body or on the adjacent land. The major physical devices employed are locks and their attendant dams, docks and piers, channel excavation and turning basins.

These devices are utilized on large waterways and harbors. The installations are relatively permanent and make navigational contact with major metropolitan areas possible. Locks and dams are permanent concrete and/or earth-filled structures created to provide adequate depth for navigation and to reduce the velocity of the water flow in order to move boats more easily. They are large, solid, normally linear in form and composed of several parts. They are used most often in Undulating Land and Flat Land Series.

Visual Impact

Because locks reduce velocity and increase depth, they often remove exciting rapids and waterfalls and decrease visual interest.

The impoundments and water storage areas created above the lock and dam change the character and visual impression of the water far upstream. Most often the water body, although larger, is less interesting because water flow is slower.

The locks are composed of several parts but in mass are simple, low silhouette structures which offer minimal contrast when viewed from a distance.

Boats that are large in relation to a river or channel are exciting visual phenomena and provide a strong contrast by both their form and size.

Cultural Impact

Navigational use may limit other uses of the water course such as fishing, swimming and boating.

Tourists as well as local residents are attracted to commercial water courses because of the visual interest they offer.

Ecological Impact

Depending upon flow characteristics of the river at its mouth, improvements for navigation through excavation may shift estuarine conditions upstream. This is most likely to occur when the natural gradients of the stream are steep and when the excavation reduces them in deepening the channel.

Construction of piers, bulkheads and dockheads may reduce fish and shellfish habitat or fish breeding areas by changing the configuration of the bottom and the banks and by the removal of natural bottom and bank materials and their replacement by other materials.

VISUAL ASPECTS AND IMPLICATIONS OF WASTE WATER MANAGEMENT IN THE MERRIMACK RIVER BASIN
(A PRELIMINARY ASSESSMENT PART 2)

For: Division Engineer
North Atlantic Corps
of Engineers

By: Walter Cudnohufsky
Environmental Impact
Consultant

July 17, 1971

This supplementary report should be read in conjunction with the original report of the same name dated May 27, 1971.

It is made both necessary and possible by the alteration of the proposed management system alternatives, by more explicit locational and physical data, and a more direct and intimate knowledge with the basin itself. With this in mind the discussion to follow will address itself to three of the initially proposed questions:

> What are the potential visual and cultural use impacts of alternative waste management systems and processes?
>
> To what extent are these impacts generally positive or negative?
>
> What are the existing land use potentials and constraints in the Merrimack landscapes?

This discussion will by necessity continue to remain general in its assessment. It will be presented with the emphasis upon both large scale locational planning decisions and small scale site design decisions. It will discuss both the physical characteristics of the systems and extend the discussion of the existing physical conditions present in the Merrimack landscape, these last two factors being the joint

contributors to visual impact.

ADDITIONAL GENERAL COMMENTS:

As stated in the first report, one of the most compelling aspects of this coordinated effort of waste water management is its potential to lead to wise and effective land use planning. It should be stressed that such potential will not be realized through the meeting of projected needs based upon population growth trends. This potential can only be realized by going far beyond the projected water quantity demands and being as comprehensive as possible in the waste water treatment for all types of industrial waste.

If industrial pretreatment of industrial waste is demanded before being accepted for further treatment, this may effectively preclude that industry from locating in the Merrimack, thus bypassing its value as a planning tool. It is suggested that through carefully locating regional STPs near existing industrial centers, and supporting legal zoning constraints developed to foster high polluting industrial zones, the major stumbling block of this issue may be eliminated. Separate collection facilities may thus be utilized to handle shock pollutant loads at the regional STPs and not forcing this burden upon the locating industries. Providing this service at fixed cost per effluent class along with the

extra quantities of available water would be effective measures to maintain controls over larger segments of planning.

A clear statement of the development incentive produced by accessible effluent transmission lines should be made. The giving and holding of such services and their exact locations have been and will continue to be key issues as to the development of an area. A policy decision on where and how much development an area should have would be useful for transmission line location. It is quite obvious that a management scheme that has equal access to all areas of the basin by connecting transmission lines is losing the control it has by carefully placing smaller quantities of those lines. A scheme with 25 miles of transmission lines may provide more control on growth than a scheme with 250 miles of such lines.

An important issue in terms of policy may be where to have the cleanest water and where to implement action first. A logical priority would be to place emphasis most quickly where the most people are located. This is of course in urban areas where the pollution is also located. To have it clean in urban areas it must be cleaned upstream as well. So the policy of putting the money where the people are intimates

dealing with entire river basins at one time. The differential impact on planning will thus be greater between basins rather than within basins.

Another policy decision that must be addressed is whether an attempt should be made to maximize the visual and cultural use impacts over large areas or maximize the amounts of impact or control within limited specified areas. The choice made in this regard will also have a bearing upon the water management scheme chosen. Reduction of the planning impact and enlargement of the area or reduction of the area and increasing the control is the issue.

Land within the basin, suitable for land disposal is limited in quantity and fixed in location. In this regard it will have a reduced potential to guide planning for large areas of the basin. Land disposal systems then, even though they are effective planning controls, are severely disadvantaged in the New England landscape. Careful thought must be given to those areas adjacent to and within the proposed land disposal areas to mitigate this disadvantage in flexibility and to insure that it is thus not harmful in its planning control. The railroad holdings along the river and quite often right up to the river are extremely valuable because

they control the land water edge and the access. It seems that a tremendous opportunity exists to enhance physical visual access to the river by gaining control of these railroad lands. This may also facilitate transmission of waste water more easily.

CRITERIA FOR IMPACT EVALUATION

A. Scale

The amount of area and the population directly affected

B. Location

Whether the system is responsive to natural and cultural landscape variation

C. Planning Opportunities

The planning opportunities and constraints inherent in the system with particular reference to multiple use, large area land use control and physical compatibility with the community

D. Type of Impact

Whether the impact is generally negative of positive

E. Flexibility

The flexibility of the system in terms of location, size, physical composition and relation to existing treatment facilities.

MERRIMACK LANDSCAPE

Additional map study and field trips have afforded the opportunity to discern some visual defferences in the landscape between the northern New Hampshire portion of the basin and the southern New Hampshire and Massachusetts portion of the basin, primarily below Nashua. Differences also exist between the immediate riverscape and the larger river basin landscape. The variation in gross terms is along its length and in its immediate versus its larger context.

The upper Basin has a variation in topographic elevation change adjacent to the river. It varies from flat flood plain to steep banks on one or both sides of the river to occasional steep hills adjacent to the river. This modulation of topographically contained space is one of the most interesting aspects of the upper basin.

There are very few ponds or river width variations to provide visual interest at the macro scale. The width, alignment, vegetation type and height, and water surface and flow are very uniform at the larger scale.

Major portions of the upper river have the railroad directly adjacent to the river edge. This is often detrimental because of the excavation often needed for the railroads' roadbed and the reduction of visual physical access to

the river.

The majority of the river edge, even in open land settings, contains a line of mature vegetation, thus softening the potential visual controls, and eliminating potential visual variation. This vegetation also stabilizes bank soils and thus avoids unsightly erosion.

The roads are generally several hundred yards from the river and do not respond to the alignment of the river, thus missing a visual interest opportunity, and do not afford many views of the River for the thousands of passing motorists.

The population density is low, the towns small, and the major population directly adjacent to the river. The river corridor for its entire length contains the majority of urbanization, the majority of transport routes and the majority of open land. The Northern Basin has large tracts of uninterrupted forest land. Visual interest is reduced in those specific landscapes where the forest quality is not high and the topography unvaried.

The Lower Basin has more variation in river width, most particularly in the Nashua River. The alignment of the old river is slightly more varied. The Nashua River exists in a

relatively undeveloped natural corridor. This is not as true for the main stem Merrimack.

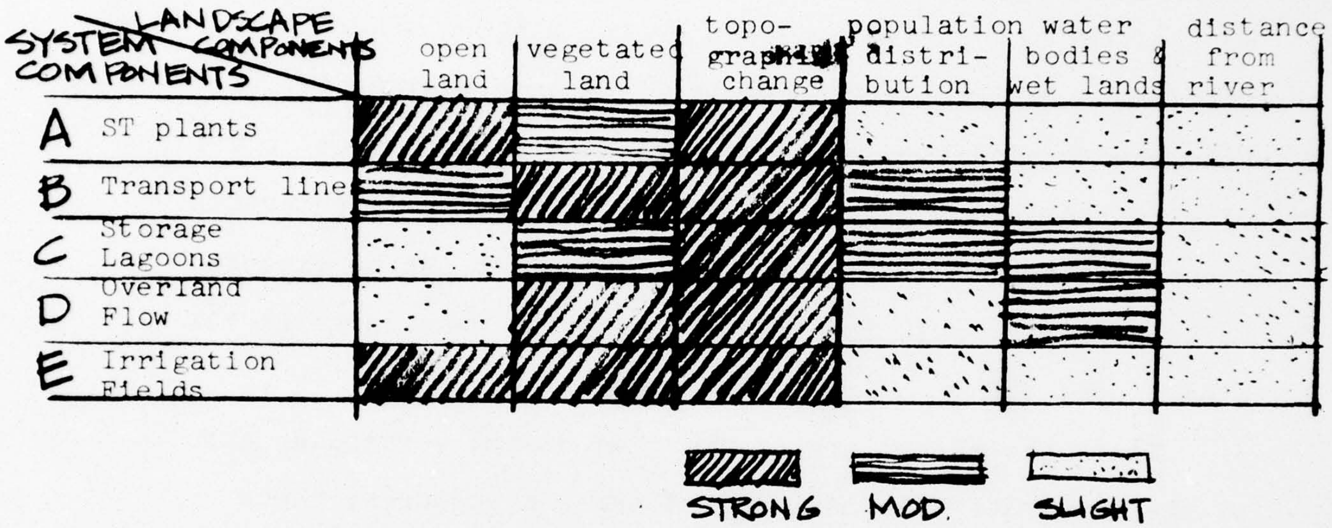
More urbanization exists in the southern basin directly adjacent to the river. This structuring is more contrasting to the larger open space of the River and more contrasting to the materials of these structures.

Open land is somewhat more extensive in the Massachusetts portion of the Basin and is generally well distributed. It does, however, need to have additional open lands to maintain its quality under development pressures.

The forest tracts are smaller in the Southern Basin and density of development is also more uniformly dispersed.

The following matrix outlines the interaction between major management system components and some major regional landscape attributes of the Merrimack. The discussion of each interaction will be found under the appropriate letter. Only those with a strong negative or positive interaction are discussed. Those with only moderate or slight interaction are not discussed.

VISUAL INTERACTION



A. The treatment plants when placed in existing open land are potentially visible from a larger area. This visibility could produce a negative or positive impact on large numbers of people, dependent upon design considerations. If located in large open areas as attempt should be made to locate it adjacent to the edge of such a space and begin to integrate it with the edge structures, topography or vegetation containing the open land.

Treatment plants because of their size and demand for open areas of operation are best located in mature wooded conditions preferably a mixture of deciduous and evergreen, or a predominantly dark green contrasting evergreen forest.

ST plants are intolerant of large (20'+) topographic change and thus would be located on relatively level lands most often in the river valleys or its plateau land. Any attempt to design a treatment facility into a dramatic topographic condition would be desiralbe from a visual point of view but is not practical. Since topography is generally steeper in the northern part of the basin it can be expected to be more difficult to effectively locate many large facilities there.

Since the plants are of the same design vernacular and of the same materials as other of man's structures, their development in densely populated urban areas should not be precluded. This however should be done with regard and control over odors and compatible adjacent land uses.

Wetlands and water bodies are inappropriate in most cases as locations for ST plants. The edge of a lake, however, may be a necessary place for such a facility. In the Merrimack Basin, with its paucity of water bodies and land water edge, this should, however, be avoided if at all possible.

ST plants will very often be located directly adjacent to the rivers. In the Merrimack Basin there are few such non-floodable sites available for any type of development. Should multiple use or competitive use be considered it may be more desirable to move the plants away from the river

edge and thus reduce its visibility and make such a location available for an alternative use.

B. Since open land in the Merrimack Basin is most often the flat river valley lands that are fertile and remain viable for agriculture, transport lines that are below ground in these areas will have little effect upon the landscape. If, however, these lines were surface structures, there would be considerable bisual and physical disruption to one of the key visual resources of the Basin.

Transport lines traversing forested areas and areas of topographic change have significant effects upon the surface vegetation and form. This can be a visual advantage to opening up visual and physical access to the landscape if straight cut line clearing practices are not used but rather a varying width of vegetative clearing. These transport systems can also be combined with highway, railroad, and power transmission lines and mitigate some of the negative visual impact. The size of these transport facilities and the extra cost of controlling a larger easement usually forces the use of quick straight access roads for large equipment and a minimum easement width. Under these conditions the transport routes will produce and negative visual impact upon the Basin.

The transport facilities, if subsurface, will be more

easily integrated in a more intensively developed area because of the lack of contrast with the existing manipulation of the earth. If the transport facilities utilize the few remaining natural green corridors in such an area to reduce economic cost, the visual cost will be extremely high for those people. It will have eliminated a portion of the visual variety in their immediate environment.

The outfalls of transport facilities into lakes or rivers needs careful design attention. The land water edge is an extremely visible and fragile portion of the landscape. An inappropriately located outfall will thus be highly visible and reduce the quality of that visual scene.

Wetlands should not be used for transport line location because of their susceptibility to visual and biological damage.

Transport lines should not be surface but rather sub-surface if at all possible. They should not restrict physical visual access to the river itself as the railroad and its embankment so often do presently. The introduction of this line along the river edge, however, provides an opportunity for selective vegetative clearing to open up visual access to the river, which is so desperately needed through much of the river's length.

C. Storage lagoons are likely to be more visually beneficial to the large scale landscape if they are located in wooded rather than open land landscapes. The size and nature of these lagoons should preclude short distance viewing and emphasize long distance viewing where these lagoons are a contrast to the landscape pattern.

They should be located as often as possible in natural topographic basins to minimize the amount of earth movement necessary to construct them. If the earth must be moved to construct them they should respond to the existing contours in the area. They should be located in less densely populated areas and thus are more appropriate in the northern rather than the southern basin.

Water bodies are deficient in the Merrimack landscape, suggesting that existing lakes should not be drained and used for storage. Wetlands upon occasion, if proven to be in perched water conditions and are not otherwise valuable to society, may upon occasion be considered for a lagoon site. This should be done after careful examination only.

The corridor along the river contains the most people and development, the transport routes, the most open land, etc. These conditions suggest that lagoons be located at consider-

able distances (hundreds of yards) from the river, especially in the southern Basin. This will mitigate the visually contrasting and disruptive capacities.

D. Overland flow will have a minimal negative visual effect upon steep open land, forested land, and topographical change. It is visually complementary in vegetated areas and is slightly complementary in open lands when the irrigation is operating and the excitement of spraying water is visible. It does limit physical access for microscale viewing.

Overland flow is best located in low population areas which exist both in the upper and lower basin.

Overland flow should not be utilized upon wetlands or directly adjacent to lakes or rivers. Visually the impact is minimal but outfall conditions preclude that type of location. It may also alter water table and quality and thus kill vegetation or change its composition thereby altering the visual image.

E. Irrigation fields are used in open land and are visually stimulating because of the transient effects of light and wind on moving water. Even level topographic conditions afford views of irrigation because of the height of the spray. This view is especially stimulating from a high

viewer dominant position looking down on the open land irrigation and discerning its pattern. Thus irrigation on flat land adjacent to accessible steeper topographic conditions is a positive condition and does exist at many points along the river.

Irrigation would of necessity be located in lower density population areas. The relative distance from the river is usually irrelevant.

Should vegetation be cleared from existing forested lands for irrigation purposes the tremendous visual advantage of open land would be achieved.

VISUAL IMPACT ASSESSMENT

Since water management schemes are site specific in their visual impact this discussion will concentrate on the regionally pervasive land disposal schemes with only a generalized statement about treatment plant location.

Land Disposal Schemes

Fitchburg Nashua

The Nashua River is located in a uniquely undeveloped natural landscape corridor. This condition would be visually

improved in some locations by clearing for irrigation and transport line location. This would however, likely promulgate development pressures.

The flat land in the area is advantageous for irrigation and clearing of some forested land is desirable.

The lagoons are proposed on Fort Devens, and would require clearing of land of which the remaining wooded context would be a desirable visual contrast. The limited access to the lagoon site may be desirable.

The pump house location is typical of most treatment plant locations in the Basin. It is near Leominster in an area of wetlands, gravel, and industrial development. Route #2 passes nearby, affording great visual access to the facility. Some one hundred foot embankments exist in the area and the relation of the mass, form, height, material, and location of a plant to the major land forms would dictate the visual success or failure of the facility.

It is generally a good location for such a facility. The land is open in parts and wooded in others, topography not too steep, a variety of viewing positives and distances are possible. It blends with the existing industrial development. (This description is indicative of most treatment plant

locations for the water schemes and the combination land-water disposal schemes and should be read in conjunction with each of them.)

Lowell Lawerence Haverill

This area is rather intensively developed, containing large mill structures. Integrating treatment plants into this developed context should be relatively easy. The plants should be placed in close proximity to such development rather than in a rural setting.

The land disposal in the open but semi unique Maine Desert would pose some legal questions. The consequences of long distance transport discussed earlier would be manifest in this scheme.

Hudson Salem Nashua

The proposed irrigation in this area is effectively clustered for local visual variation. Some advantageous clearing would be necessary, and an impetus to some agriculture seems probable. There are some large tracts of existing agricultural lands available. The major issue is the highland location of large lagoons in a settled and developed rural town landscape.

Manchester

The major issue in this area is the long transmission lines needed through rugged wooded terrain to the suitable irrigation sites. The population concentration on poor irrigation soils forces large scale disruption. Open land is needed in this area and if properly designed these transport lines could not only give that open land, but guide development with it as well.

Northfield Suncook

Lagoon sites will require extensive land manipulation. Their site location below Franklin will disturb few roads or houses. There is good farm land for irrigation.

Overland flow sites would not visually disturb the landscape. In overland flow sites clearing of open land in wooded landscapes should be considered both for the visual interest and possibly to speed evaporation. This scheme would take full advantage of the visual advantages of the overland flow method.

Concord

Overland flow and irrigation are both visually advantageous in this area. Transport distance would be reasonably short but over rugged terrain. The storage lagoon would

again require large scale land manipulation.

Overall Impact of Plans

The visual impact of the three alternative water treatment plans is minimal and site specific except for the longer transmission facilities needed for alternatives 2 and 3. This impact of transmission lines can be either positive or negative depending upon the natural conditions and the design of the facility.

Since the urbanized areas are generally located upon flatter landscapes, alternative 2 is quite easily accomodated. Alternative 3, however, includes significantly greater transmission distances across more rugged topography and it would be more difficult to produce a positive visual impact.

The land disposal system is regionally pervasive in its impact. The storage lagoons, transmission facilities, and irrigation lands are the main components of visual impact.

Transmission in the land scheme far exceeds the length associated with alternative 3 of the water schemes and would suffer the same constrainst. There is variation between sub parts of the land disposal plan which are explained under the interaction matrix and the appropriate titles.

The storage lagoons will be the most difficult part of

land disposal schemes to visually integrate into any landscape. Even though water bodies are a visual advantage in most Merrimack landscapes, this type of waste water is not necessarily an advantage.

The effects of irrigation are variable by the season and day and are less pronounced than the effects of lagoons, unless clearing were necessary for its installation.

The three combination plans share the traits of their component land or water disposal plans. The more regional the PC plant the greater the amount of transmission necessary.

The combination of summer land/ winter water plants (combination schemes 2 and 3) is distinctly advantageous since it eliminates lagoons, the most severe limitation upon the land systems' visual impact.

Combination scheme 1 has reduced transmission distance and has concentrated land disposal in New Hampshire where the land is most useful for irrigation, but it has not eliminated lagoons.

Combination scheme 2 is potentially the most visually advantageous with reduced transport distance and elimination of lagoons.

INSTITUTIONAL, VISUAL AND ECOLOGICAL ASPECTS

OF WASTE WATER MANAGEMENT

IN THE MERRIMACK RIVER BASIN

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17 June 1971

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I. INTRODUCTION

This paper is addressed to the problems and opportunities attendant to the institutional, visual and ecological aspects of wastewater management in the Merrimack River Basin. It is general in scope - a first approximation - pointing out major problem and/or opportunity areas and those issues or questions demanding additional study.

The paper is based, in substantial measure, on information presented at the Wastewater Management Workshop held at the University of Massachusetts (17-20 May 1971); on the individual reports of Dr. Hugh C. Davis, The Social-Institutional Impacts, Professor Walter Cudnohufsky, Visual Aspects and Implications of Wastewater Management and Dr. Carl A. Carlozzi, Ecological Impact of Proposed Alternative Waste Water Management Systems; and on the NAR Appendix N, Visual and Cultural Environment (1970).

The paper is organized in three major sections. The first presents a brief discussion of the general environmental setting of the basin and of certain physical, cultural and political dimensions. The second section focuses on several potential problems of any waste water management program in the Merrimack Basin, regardless of the technological system employed, on several environmental issues or opportunities that could be influenced by one or more of the proposed management systems and on general principles applicable to the study. The

third section is an analysis of the potential institutional, visual and ecological impacts of the several alternative management systems.

II. THE ENVIRONMENTAL SETTING

The term environmental setting as used in this paper encompasses the physical, cultural and social characteristics of a region. Three dimensions of the Merrimack Basin setting are briefly outlined in the following paragraphs. They are dimensions which are directly related to the institutional, visual and ecological aspects of waste water management. The first two dimensions, land form and land use pattern are based on work done for the NAR Visual and Cultural Environment, Appendix N (hereafter V & CE). These dimensions relate to the macro-scale physical attributes of the land and to the type, intensity and distribution of different cultural activities on the land. The third dimension relates to the way in which the land is organized into political divisions for administrative and decision making purposes.

The land form ranges from rolling hills in the south and central sections to mountains in the northern section of the basin. Steep hills are dominant in the North between the mountains and rolling hills - around the Lake Winnipesaukee area - and in the western section. The NAR, V & CE classification and inventory data on the basis of the dominant visual-physical features (Landscape Series) are:

Mountains:	400	square miles
Steep Hills:	1400	square miles
Rolling Hills:	3200	square miles

Superimposed on this land form base are cultural land use patterns. Along the river there are a range of patterns. Elsewhere in the basin however, the pattern of land use is fairly homogeneous. The NAR, V & CE data on land patterns (Landscape Units) are:

City:	600	square miles
Farm-Forest:	500	square miles
Forest-Town:	3500	square miles
Forest-Wildland:	400	square miles

The Forest-Wildland is coincidental with the White Mountain area and is characterized by very few open areas (cropland or pasture) and by low population densities of less than 100 people per square mile. The City Units with population densities of 1,000 to 10,000 people per square mile are an extension of the Boston metropolitan area. They are located along the river, primarily in the lower one-half of the basin, extending south from the Concord-Manchester area. The Farm-Forest pattern, in which 20 to 35% of the area is in cropland and pasture is located along the river between the city areas to the south and Lake Winnipesaukee to the north.

Within the remainder of the basin, which is in Forest-Town, the Lake Winnipesaukee area (about 1200 square miles) is a resource of considerable value to New England. It is a major year-round inland vacation area within 2½ hours

driving time of the Boston metropolitan area. It is also an area of outstanding scenic quality with the juxtaposition of a large freshwater lake, the White Mountains to the north, rolling hills and river valley to the south and a mix of land use patterns - Forest-Wildland, Forest-Town and Farm-Forest.

The third dimension to be touched upon in this brief essay on the environmental setting is that of governmental roles within the region. The basin lies within two states, New Hampshire (3,800 square miles) and Massachusetts (1,200 square miles), and within a region that has a number of developing regional organizations such as the New England River Basins Commission and the New England Regional Commission. Local government is, however, a very strong force in New England in difference to many other parts of the country where counties occupy positions of greater strength. This local strength expressed in the town form of government can complicate the problem of developing intergovernmental arrangements simply by virtue of the greater number of governmental units involved. Regional organizations can be of assistance in developing programs and mapping strategies but local governments can be the deciding factors in making key decisions. This is particularly true when the decisions relate to land use and the local tax base. Control of the former is almost exclusively vested in local governments.

III. PROBLEMS, ISSUES AND OPPORTUNITIES

There are a number of problems, issues and/or opportunities which should be considered regardless of the technology adopted for waste water management. They are presented in this section in the order of institutional, visual and ecological concerns. The major points for both this and the following section are taken with limited editing from the Davis, Cudnohufsky and Carlozzi reports.

INSTITUTIONAL CONSIDERATIONS

Whether disposal is done by water or by land, substantial cooperation and coordination at local levels of government must be accomplished. This is not an easy task, particularly in New England where the town form of government is strong. The implications of this are clear. Either inter-governmental cooperation is brought about through an extensive (and imaginative) public educational program throughout the Basin or legislation requiring such cooperation must be worked through appropriate decision making bodies.

Much of the Basin does not at the present rest on a strong economic base. Several of the major industries are not now economically strong, nor is there much indication that their situation is likely to change for the better in the decades ahead. If additional costs for primary treatment are to be assumed by the individual firms involved, one can

safely predict that a number of local firms will close. This can have strong public and political overtones and should be carefully studied on a firm by firm basis.

A similar situation will exist in many of the smaller units of government. Property taxes throughout the Basin are already high. Local governments in many cases will find it difficult to produce the needed additional revenue for primary treatment even if beneficial cost-sharing is available, and costs of advanced treatment could still further aggravate the situation.

Changes in the value of land abutting the Merrimack River may occur as a consequence of the improvement in water quality. If this should happen, then some increase in the local tax base will result, but it is doubtful that this new source of income to local governments will be sufficient to meet the new costs of waste water disposal.

An important question is how land use along the river and its major tributaries may be effected by the project. A study should be made of possible land use changes that might be expected, and how, if desirable, these may be controlled and regulated.

Recreation use of various types on and along the main river is a most likely possibility. How and what kind of facilities should be developed, and who will do this (public, private or a comination) can have a strong economic and social impact in the Basin. The topic needs careful consideration as the planning stages advance. Properly worked

out, water based recreational activities within the Basin could strengthen the already established tourist and second home industries of the upper portions of the Basin. This would be particularly true in the Lake Winnipesaukee sub-region, long used as a vacation area for the metropolitan regions to the south around the greater Boston area.

VISUAL ATTRIBUTES

The greatest landscape value within the Basin is presently concentrated in the river valley culminating at Lake Winnipesaukee and the White Mountains. The river valley also provides the corridor up which transportation networks and urbanization move creating the potential for the linking of Lake Winnepesaukee with Boston via suburbia. The existing visual quality is in large part a product of diversity - of the juxtaposition of different physical and cultural dimensions. The potential for the diminution of this quality lies in the potential loss on the cultural dimension - loss of the open space and in particular the open land (farmland) along the river.

Inland from the river the pattern of land use is fairly homogeneous. The White Mountains in the northern section however provides a dramatic third dimension which more than compensates for the lack of pattern. (Pattern is more nearly two-dimensional in the distribution of towns, farms, forests and water on the surface of the land).

Opportunities to enhance and/or maintain visual quality of the Basin at the regional scale are related primarily to the problem or issue of pattern. The maintenance of open field farmlands in the area between Concord-Manchester and Lake Winnipesaukee is important within the river corridor. The careful addition of land use activities such as open fields and surface water, creating more diverse patterns in the inland areas, could do much toward enhancing the visual quality of those areas.

The creation of a clean river will also provide an opportunity to enhance the city environments by reclaiming the urban waterfronts for open space and public parks. Most of the cities have turned their backs on the rivers using them for industrial development and disposal of wastes. As a result the rivers have been lined with buildings and structures which have prevented both physical and visual access to the river. It was neither desirable nor possible to see the river or to get to it. A change in the industrial structure of the region and concommitant locational requirements coupled with clean water provides remarkable opportunities for the provision of urban amenities. The utilization of the water surface as a natural open area, the development of open spaces within built-up areas and the provision of access to water oriented activities in the center of the city become feasible urban design objectives. The river can function as a dominant element in the development of an urban open space system which is linked visually and physically to the countryside.

ECOLOGICAL FACTORS

There are a number of general factors or considerations which are basic to the understanding and assessment of the potential ecological impact of the various waste water management systems. Included are: fundamental ecological parameters of energy flow, the nutrient cycle and the hydrologic cycle, bioclimatic responses, the substrate and growing media, and several aspects of ecosystem stress.

Fundamental Ecological Parameters: There are three principal sources of energy reaching any area of the earth. The first is short-wave radiation from the sun. The second is the geologic forces essentially including the potential energy of gravity and the forces of vulcanism, surface uplift and subsidence. These, in combination with the presence of water with high latent heat, produce a general and localized atmospheric condition averaged over a long period -- climate.

The basic nutrients we are concerned with are nitrogen, phosphorous, potassium, calcium and iron, as well as the gases oxygen and carbon dioxide.

Under existing technology we are still mostly concerned with the expression of the hydrologic cycle as it appears on and beneath the land.

Bioclimatic Responses: The biota making up any particular region exist at the interface of the three energy inputs. The biota exist, therefore, in response to the proportions of solar input to

geologic energy input to atmospheric energy input in any one place. The major long-term phenomenon which produce the biota of any region is the genetic evolutionary capacity of life to create new species and thus create new living forms and functions.

In the shorter run the process of speciation becomes less important and the process of biotic succession becomes more important. This process is one by which any area of land or water is successively invaded and dominated by a series of plants and animals generally tending towards increasing diversity and complexity in order to arrive at something approaching a steady-state condition between total production and total respiration during any annual cycle. In addition, the generally mature climax stage of succession produces production/respiration (P/R) ratios approaching one with very little amplitude of change in P/R behavior through time.

The concept of the closed system is one which is very important to the maintenance of ecological performance on a continuing and efficient basis. This is accomplished by the system building the mechanisms to retain essential materials (nutrients) in place, cycling them slowly and evenly from primary producers to consumers and then to the microflora and fauna which return the nutrients to the air and soil for uptake into new growth.

The relatively closed nutrient and gas cycles are accomplished through the increasing feedback mechanisms arranged among and within the structural layers of natural communities. These layers are described as Life Forms. At the highest level the

dominant vegetation is generally structurally dominant. There is a progression down through lesser layers to the level of the soil and the microbiotic organisms of the soil. In a sense one can see each structural layer of a natural community as a broad habitat supporting its own respective population of consumer organisms at several trophic levels.

Substrate and Media: For all living things there is a necessity to have a basic substrate for anchorage and supplies of nutrients, and all living things are surrounded by a growth medium. For terrestrial organisms, soil is the essential substrate and air is the medium. In the case of many aquatic organisms, water is both the substrate and the medium, though for rooted aquatic plants and sessile aquatic animals the channel or basin bottom may act as the substrate. Within the substrate and the medium there is a general need for continuity of chemical quality and quantity through any annual cycle of natural growth and reproduction. This continuity does not mean a constant amount or proportional arrangement of chemical substances within the substrate or medium each day of the year, but rather a constant pattern of chemical conditions which is more or less repeated year after year, season after season.

There is also a need to maintain continuity of physical conditions on the same basis as chemical quality and quantity. It is the pattern of temperature changes and other energy inputs into an environment on an annual basis that constitutes the physical parameters within which speciation

has occured, succession has taken place, and the adaptive amplitude of any individual species making up the community is determined.

Ecosystem Stress: Because the surface of the earth, the atmosphere, and the amount of short-wave radiation reaching the surface of the earth are never constant through long periods of time, it can safely be said that all living systems exist under a state of environmental stress. These states of stress can be grouped or classified as long-run or short-run.

Long-run stress in the form of geologic changes tend to be related to the basic geological processes of vulcanism, tectonics, and long-run peneplanation. Climate changes (also long-run stress) are related to patterns of occurance of climatic phenomena which produce conditions of hot, dry, cold or wet environmental conditions. These patterns express themselves seasonally or on a diurnal schedule but in the long-run retain a considerable constancy. This is due to the fact that short-wave radiation inputs acting on the surface of the earth with subsequent entropic breakdown to long-wave radiation create sufficient energy on land and atmospheric water to produce the basic seasonal and diurnal distribution of hot, dry, cold, wet conditions for any one place.

The short-run geologic change phenomena tend to be localized in geography or instantaneous in time. These can be local earth movements such as earthquakes, land flows and erosional patterns.

Their effect is usually brief and tends not to alter the basic distribution or structural arrangement of the biota, except on the site effected.

Aberrations in the behavior of weather may produce short-run local stress. Low probability precipitation patterns, early frosts or late springs, droughts, hurricanes and tidal waves are examples of short-run stress of this category. Once again, such stresses tend to be localized and may be significant for the area affected, but they usually do not change the overall pattern of speciation or structural arrangement of biotic communities within a bioclimatic region.

In response to stress the ecosystem behaves essentially like a "cybernetic system" -- that is, it has three fundamental capacities: it is self-creative, it is self-repairing, and it is self-adjusting. Basically the self-creative function is related to genetic evolution and the capacity to develop new living forms and functional diversities through long periods of time in response to the more profound, long-run stress factors. The self-repairing capacity is generally expressed as the successional series of developmental communities leading to the more stable, mature ecosystem. The self-adjusting capacity is related to the adaptive amplitude of each individual species to endure under the normal patterns of annual, seasonal, or diurnal changes in physical mechanisms of the individual organisms represents the shortest run capacity to deal with stress.

The most fundamental change which human beings in their activities exert upon the stress patterns effecting ecosystems is the charge in the time distribution of events and/or substances as they occur in the environment. These changes would be exemplified by the following activities:

1. A removal of inorganic and organic stock from a place faster than growth or import systems can replace stocks.
2. An import of inorganic and organic substances and energy to a place faster than assimilation and growth systems can adjust to the imported factors.
3. Alteration of the regimen of water on the land and to a lesser extent in the atmosphere.
4. Development and introduction of substances or energy, either in kind or intensity, outside the evolutionary experience of the genetic stock making up the ecosystem in question.
5. Acceleration or retardation of natural geologic processes, especially that of peneplanation.

Removal of the biological system's "cybernetic" capacity would be accomplished by any of the following occurences:

1. The extinction or the extirpation of species from an ecosystem.
2. The alteration of the structure of natural communities. This could occur, for example, by the removal or the degradation of one of the life form layers of any community, thus reducing the spectrum of its habitats and causing a loss of its dependent animal and microbiotic flora and fauna.
3. Forcing the biota of a place to exist at any extreme of their adaptive capacity as a general life condition.

IV. INSTITUTIONAL, VISUAL AND ECOLOGICAL IMPACTS

The potential institutional, visual and ecological impacts are presented in the following pages by type of management system. Two broad, yet distinct types of management systems have been proposed for consideration in the basin: disposal on the land, and disposal in water. All treatment systems for water disposal, physical, chemical and biological, are grouped together and are discussed first. Land disposal is discussed second and is further divided on the basis of flooding-basin, irrigation and overland flow techniques. The lack of detail in reference to specific locations for any of the techniques limits the discussion to general terms. The three alternatives of land disposal offer more distinct institutional impacts than is true for water disposal. However, where this is done,ie. in or out of the Basin, will pose somewhat similar impacts as those mentioned in connection with water disposal. Where possible, sub-regional considerations are also given for the Boston, the Lowell, Lawrence, Haverhill, and the Winnipesaukee areas.

WATER DISPOSAL - PHYSICAL, CHEMICAL AND BIOLOGICAL TREATMENT SYSTEMS

Institutional Impact (also see the last four paragraphs under Land Disposal-Irrigation).

- At the present state of planning as set forth by the consultants, there do not appear to be

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many unique institutional impacts peculiar to the different water disposal techniques suggested for the various sub-regions. Whether treatment is by physical-chemical, biological or a mixture of these, the impact would be quite similar to that of any major investment and land use change. For example, changes up or down, in land values in areas adjacent to the installation are to be anticipated along with local citizen support and resistance to these changes. It is quite possible that minor impacts will result in association with zoning regulations, particularly in the lower reaches of the Basin.

- The specific locations of water treatment return will undoubtedly have a bearing on which segments of government in the Basin will actively support the program. Certainly if the water, once treated, is released outside of the Basin, regional resistance is likely to be of a much stronger nature than if it is returned directly back into the Merrimack. Consideration of the water return points should also be given regarding its effects on the potential of attracting new industry into the Basin which may be drawn by the availability of high quality water.

- Both the location of treatment and the points of discharge are factors having the greatest potential institutional impact other than the

over-all costs. These should receive study both from the economic and the political viewpoint. This applies for each of the sub-regions as well as the Basin itself. It should be anticipated that alternative locations could produce substantial differences in their impacts on local economies.

Visual Impact

- The visual impact of water disposal systems are substantially less than those from land disposal primarily because of reduced land area requirements.

- Water disposal has several direct visual effects upon the water course where the treated effluent is discharged. First the flow is made more regular during normal low flow periods and thus is made visually more appealing, and second, the return of very low nutrient treated water should produce clearer, more attractive water in the stream.

- Several water treatment facilities common to both biological and physical chemical processes are potentially significant. Treatment tanks are the main feature of both processes and occur either in the open or under cover. Tanks in the open are often buried so that only a small portion is visible from a normal viewer position such as from a car. The visual impact is thus reduced. Tanks that are under cover produce large bulky

rather boxy forms that can be incongruent both in context and in their scale impact on local areas.

- There are normally a series of buildings that house the various steps and activities in the process. They range in size but are normally quite large and low in profile (measured in acres).

- Filter beds and storage reservoirs are also attached to many water treatment facilities and are generally in the open, geometric in form and low in profile. They are normally clustered in larger groups and can be contrasting elements in the surrounding landscape because of their need for level land.

- Furnaces and stacks are the only taller vertical elements that are connected with waste water treatment. Stacks can be dominant focal points in the landscape and also emit gases which detract from the visual quality of any landscape.

- Mechanical equipment such as piping and related objects is normally associated with tertiary treatment, (e.g. physical-chemical processes). These mechanical features, if appropriately grouped, can add visual interest to an otherwise dull and blocky treatment facility.

- Boston Sub-region: The visual dominance and contrast of incineration stacks provides a strong constraint upon the location of facilities. Consideration must be given to the safety feature of not being up-wind of densely populated areas as well as its visual impact on local buildings, features and landscapes. The facility is compatible in scale and character with industrial buildings and could be integrated into industrial districts. Use of the harbor islands for these facilities however would be inappropriate. The uniqueness and the scenic value of the islands would be lost under such large scale development. The question of one or of several plants makes no significant difference except that the misuse of a major environmental resource would be compounded.
- Lowell Lawrence Haverhill Sub-region: The same issues would probably apply in this sub-region as in Boston. Potential sites would be more restricted if facilities had to be located on the main stem of the Merrimack River rather than only discharging into the river from other more distant locations.

- Winnipesaukee Sub-region: This area is more natural in character and as a result, placement of large treatment facilities would be incongruent in the landscape. Location of any facilities in the area will need to be carefully done so as not to distract

from the recreational value and landscape quality.

Ecological Impact

- Since all the physical-chemical systems proposed appear to have a similar effluent output quality, considerations of ecological impact will be the same for all PC alternatives.

- The improvement of the water quality of the Merrimack River Basin through the PC systems would make Merrimack River water available for water supply for the Boston Metropolitan Region. It would appear from the alternatives offered that this water resources advantage gained would be utilized in a water supply system. This means that there will be a withdrawal of water from the Merrimack River for such water supply. Under the proposal by the Water Disposal Group it seems evident that only a part of that water will return to the river.

- It is estimated that eventually up to 30 percent of the total flow of the Merrimack might find its way into the Boston Metropolitan Area water supply system. Depending upon the time of the year of withdrawal and the rate of withdrawal as a proportion of seasonal average low flow, there could be an ecologically important change in the regimen of the lower reach of the Merrimack River.

It is difficult from the description of the water supply and waste water treatment systems to determine exactly what the pattern of withdrawal and return might be though it seems possible that roughly 50 percent of the water entering the system would be treated in a proposed South Boston facility and effluent discharged directly into Boston Harbor. The other half of the water would be treated in a North Boston facility with a probable discharge back into the Merrimack. Thus, at its intensive operation the water supply system might résult in an attrition of 15 percent of the flow capacity of the Merrimack River in its lower reach. The impact from this would be a reduction of flow and change in current, and current velocity, possibly affecting the migration of fish which orient according to current and the forces of flow. The change would also affect other more local aquatic biota which are dependent upon an existing ratio of solar energy to current flow and thermal energy. There could also be a tidal bore encroachment further up the Merrimack with a consequent habitat change in the lower reach from fresh water to estuarine conditions.

- Effluent quality of the treated water being discharged into the Merrimack would seem to be extremely low in nutrients, especially phosphorous and nitrogen. Both elements would be expected to be present at less than

1 PPM in the effluent. There is no information at this point as to what is the natural base line of nitrogen and phosphorous inputs from the land and the atmosphere. All present readings are based upon current loads of untreated waste water and thus those leads would be masking the natural base line inputs. Assuming there would be a significant reduction in nutrient inputs because of the super-clean effluent this would probably result in a reduction of primary production and a change in the composition of aquatic flora favoring those plant species which can tolerate low nitrogen and phosphorous levels.

- Disposal of the sludge resulting from the physical-chemical treatment alternatives is an ecological risk if one assumes that incineration is the means of reducing the amount of sludge. Heavy metals and nitrogen oxides could produce an air pollution condition. If one assumed storage of the sludge until the heavy metal problem can be solved, then this risk is obviated.

- In all cases one would have to recognize a considerable gain in water quality should the Merrimack River Basin be freed of its pollution load by the institution of either physical-chemical or land disposal systems. The reduction of toxic substances and BOD and COD loadings from domestic and industrial

pollution would in all likelihood result in a more diversified aquatic environment with a higher rate of primary productivity and consequently a diversification and lengthening of the entire food chain. Adding trophic levels would improve the efficiency in the feedback mechanisms to stabilize aquatic ecosystems and would undoubtedly result in a higher utility of the river for the production of fish and all other aquatic life.

LAND DISPOSAL - IRRIGATION

Institutional Impact (also apply to overland flow)

- Irrigation and overland flow disposal will both involve large land areas and large winter water storage areas. Public education toward the acceptance of either of these methods will be required. More involvement with the private sector is called for with these alternatives than with any of the others suggested. Though few details were presented by the consultants it is also apparent that more local government cooperation will be necessary to meet the demands of either of these land disposal alternatives. As mentioned above, because of strong traditional ties to town systems of government this will be more difficult to develop than would be the case in other parts of the country. However, if the Basin towns

can be shown that there will be a distinct advantage to them, there is little reason to feel that agreements could not be reached. Public education on a large scale therefore will be essential.

- Winter storage of the waste water for either of these methods is going to pose impact problems of a most difficult nature. No town or group of towns is going to be happy about storing the waste from cities during the winter months. If there were larger public land holdings within the Basin, perhaps storage would be possible, but other than Fort Devens, these do not exist. And Fort Devens is not in an optimum location for the purpose of collection or recharging high quality water to the Basih.

- Whether or not any of the land disposal methods offer opportunities for the development of new forms of agriculture or forestry is a question that needs study. A short growing season may pose some limitation but the development of specialized crops might be a possibility if the economics of waste distribution can be worked out for private lands.

- On a sub-regional basis the various alternatives, either land or water, will present different social, economic and institutional

impacts. The extremes clearly are between the more rural region of Lake Winnipesaukee and the urban Boston Metropolitan region.

- If one discounts for the moment the dollar costs of any of the alternatives, inter-regional cooperation will be the greatest need and will carry the greatest future impact. For example, New Boston, New Hampshire is not likely to welcome out of hand huge quantities of waste water from Lawrence or Boston without first being assured of some economic gain to its local government. Local resistance to land disposal will be greater because the technique involves "spreading the sewage all over the land." Whereas with water treatment most of the process is confined in a large building or two.

- Though large metropolitan governments are hard pressed for money, the economic impact of the proposed project will be less in the Boston sub-region than is probably the case for the other sub-regions. The validity of this assumption, however, will depend largely upon what techniques are decided upon and whether or not and where the treated water is returned to the river within the sub-region.

- At this stage of preliminary planning it is logical to assume that additional economic impact will result from the employment of operation and maintenance personnel for the

system, but it is not possible to speculate on the magnitude until the various alternatives are decided upon. Because of the present population sizes of each sub-region, it is clear, however, that given the same disposal techniques and thus the same number of new jobs for each sub-region, the impact will be greatest in the Lake Winnipesaukee region because of its smaller labor force.

Visual Impact

- The irrigation system of land disposal demands a large land area including facilities for water storage of effluent. It has been estimated that 124,000 acres of land would be needed for a 2 to 3 inch per week application over a 20 to 30 week period of the year. A single large storage lagoon of several thousand acres or several smaller lagoons would be required. These lagoons would be fitted to natural land forms that are subsequently graded and shaped to the proper depth to control the activity of the waste water.

- The introduction of large water bodies would normally have a strong positive visual impact on the Merrimack landscape, but the aesthetic quality of the stored waste water (e.g. color, clarity, etc.) would mitigate against the

positive impact. The large scale earth moving requirements could also detract in natural areas.

- The irrigation areas would be open, terraced fields with extensive underground water management control. The scale, form and nature of the field boundaries are critical elements in determining the visual impact. The relationship of field shape or form to the natural topographic form and the delineation of boundaries with hedge rows could create a new harmonious landscape.

Ecological Impact

- The irrigation system has perhaps the most varied and wide-spread impacts of all the proposals, be they physical-chemical or land disposal.

- There might possibly be a nitrogen and phosphorous loading of local surface waters from the effluent except for the 120-130 day growing season in Maine, New Hampshire, and Plymouth County in Massachusetts. Any disposal of effluent on the land before or after the growing season would lose the advantage of green plant take-up of nitrogen and phosphorous as a treatment device.

- Removal of permanent relatively steady-state ecosystems which have P/R rations approaching

one and substituting for them very unsteady state systems in which P/R ratios would greatly exceed one during the growing season and be greatly less than one during the non-growing period.

- There would be a reduction or an absolute loss of forest and wetland wildlife species when crops of any kind were substituted for the existing biota.

- Assuming little or no recycling of effluent in the public water supply systems, there would be a possible augmentation of coastal stream flows. These would change the physical character of the estuaries and also the salinity gradients within the estuaries in the Cape Cod portion of the system.

- The large storage impoundment constitutes a geologic change with an additional high risk of sepsis. There would, of course, be a removal of existing ecological conditions for possible non-living water environment (except for anaerobic bacteria).

- The irrigation system offers a unique opportunity to increase farm wildlife habitat if the management for such habitat is made a part of the total system. Such increase in farm wildlife would be a very real asset

to the recreation opportunities in the Eastern Massachusetts area in which farm game are the most popular species sought after by hunters. It is exceedingly important to note that with the proposal for shifting to farm products such as high-valued crops in vegetables that there would be no guarantee that farm game would be a natural condition of such an agricultural regimen. There would have to be a specific recognition of wildlife production as a planned secondary benefit of the cropping system in order to guarantee that wildlife would be present.

LAND DISPOSAL - OVERLAND FLOW

Institutional Impact (also see Irrigation)

- The employment of land disposal methods will necessitate a greater degree of intergovernmental cooperation than is likely to be true with disposal by water treatment plants. However, there will be variations in needed cooperation in either of the two general methods and also within the specific techniques finally adopted. For example, the overland flow method of land disposal would involve an extremely large amount of land area, probably scattered in different locations and involving many units of local

government. On the other hand, any combination of water disposal techniques require comparatively small acreage in perhaps not more than a maximum of a half dozen locations.

Visual Impacts

- Overland flow requires approximately the same acreage (124,000 acres) in land for disposal areas and lagoons as the irrigation process. Overland flow however can utilize less permeable soils and steeper slopes. It requires significantly less soil management. Forest vegetation could be maintained and other than irrigation pipes and a series of interceptor trenches, the existing visual context would remain essentially the same. The visual consequences of the storage lagoons etc. would however be the same as noted for irrigation.

- This system could support forest production in the basin and if desired introduce open grassland into forested situations for visual contrast and diversity. It is assumed that none of the land disposal systems would cause fly, rodent or odor problems.

Ecological Impact

- There seems to be only one possible negative impact from this system assuming that it is

as widespread in its use as anticipated. (that is, a maximum of one inch of effluent added per week to any area receiving the overland flow.) This impact is related to a possible BOD loading over tight soil pockets in the forest areas. This might result in developing anoxic conditions in the surface soils with a consequent destruction of vegetation. The seriousness of this effect is dependent upon the proportion of tight soil depressions to the total surface area being used. Were this to be a small proportion, say 5 to 10% of the total area, and well distributed throughout the area, then the loss of vegetation would be minimally important. However, should the percentage of tight soil depressions and pockets amount to more than 10% or be concentrated in several larger areas within the disposal land, then the loss of vegetation might result in the opening of a canopy and a change in the microclimatic effects. There could be a change in the insolation to the forest floor and a subsequent change in the species composition and structure of the understory layers and life forms of the forest. (There is a very slim and outside possibility that the discharge of effluent may affect the ground nesting of birds and the subsoil biota such as earthworms, small mammals and the microflora and fauna. This seems not

too likely because of the relatively small amount of effluent treatment by the overland flow means.)

- The overland flow system seems to offer considerable opportunity to increase the quality of forest site conditions. This would be accomplished by increasing nutrient availability to forest trees, thus raising primary productivity and efficiency of energy conversion. Assuming no harvest of commercial timber as a result of this, one would achieve a richer and more productive community of consumers including all forms of wild animal organisms. However, one could take advantage of increased site conditions by increasing the harvest of commercial timber and wood fiber.

LAND DISPOSAL - FLOODING BASIN

Institutional Impact

- The flooding basin approach will have many of the same institutional impacts as the two other alternatives, but in some respects would tend to concentrate the question of local government acceptance and cooperation into a few specific areas. There is no question that local public resistance would be strong since land values would be adversely affected.

Visual Impact

- The flooding basin or high infiltration technique is the least demanding on land area requirements. The visual impact of this land use could be dramatic since it would entail extensive grading of the land into level diked cells. These cells would be covered with a protective material such as styrofoam for winter operation. Even if masked by careful attention to color and texture the covered areas and land manipulation required will present problems of integrating these facilities into the landscape. The problems are caused in part because the character of this facility cannot easily reflect the rolling character of the Merrimack landscape.

- Steam and local fog would be a potential ephemeral effect from such infiltration beds since they would need to be heated during the winter. This could be dangerous to travel and destructive to nearby vegetation through ice formation.

Ecological Impact

- This system seems to require a minimum of land disturbance. Approximately six square miles of land area is required for this system and quite obviously where the system is developed all existing biota would be

removed and a rapid discharge or flooding basin would be substituted. This essentially would support little or no significant biota and thus there would be a net six square mile loss of biologic productivity. Depending upon the use of water treated by the rapid discharge method following treatment, it may or may not result in attrition of flow in the Merrimack River. If it did result in such attrition, then the same impacts as described for the PC systems would be in effect.

V. SUMMARY

The kinds and extent of institutional, visual and ecological impact caused by the proposed pilot program for the Merrimack Basin will depend to a great extent upon which of the alternative techniques are applied. At the present planning level only the most general kind of speculation is warranted. Never-the-less several comments can be made that will be useful to consider as the planning process proceeds.

- Early and aggressive study of the non-engineering and nontechnical aspects of the project should be pursued. These studies should be done at the same time and should be treated with the same importance as the technical studies.

- Though the public will probably be more intrigued by the land disposal concept (and its "recycling aspect", more institutional, visual and ecological impacts are likely to be associated with this alternative than with water disposal.

- The greatest institutional impact of the project regardless of the disposal methods adopted will be in the realm of inter-governmental regional cooperation and coordination.

- An early public education program will be called for in order to develop needed local understanding and support of the project.

- The economic impact of the project can be substantial, both in terms of benefits and costs to the Basin and its sub-region. Shifts in the kinds of industry within the Basin may be one result. Certainly recreation and tourist activity will be enhanced particularly in the Lake Winnipesaukee sub-region, and to a somewhat lesser extent in the lower two regions.

- There will be great variation in the institutional impacts, depending upon whether or not treatment is done within the Basin (particularly land disposal) and whether or not the treated water is returned to the Basin and at what specific points along the river.

- There is a slow, yet constant growth of regional organizations throughout the New England area. Properly worked with and fostered, this movement can be of major importance in realizing the project's objectives.

- Careful consideration of an "advocacy approach" to the <u>entire</u> planning process should be given. If applied this should involve people (perhaps in substantial numbers) from <u>all</u> levels of government and major citizen's interest groups. It should be initiated at the earliest possible time, as a means of gaining local understanding and support.

- The project presents an opportunity to maintain and significantly enhance visual values through the maintenance of open lands (farm fields) and the development of water oriented open spaces.

Matrix 1 summarizes the <u>intensity of impact</u> potential for a few key institutional and visual variables.

Matrix 2 summarizes the <u>negative impact potential</u> for ecological variables. In terms of long-run and most profound types of change or impacts resulting from any of the systems considered, the upper portion of Matrix 2 is considerably more important than the lower. The variables listed at the top of

the Matrix tend to move from longest run and most profound to shortest and most localized and thus weighting should be given accordingly. A word of extreme caution is needed not only in reading the Matrix which follows but also the entire text. In all instances we have almost no established base line for what are the natural phenomena which might be affected in medium and short-range activities. In all instances it is highly recommended that specific research activities be instituted to develop such base line information in order that departures from those norms can be assessed following the implementation of portions or all or any of the proposed waste water treatment alternatives.

MATRIX 1

•INTENSITY OF POTENTIAL INSTITUTIONAL AND VISUAL IMPACT

POTENTIAL IMPACT	DISPOSAL SYSTEMS: WATER	IRRIGATION	OVERLAND FLOW	FLOODING BASIN
Land Area Requirements	L	H	H	M
Intergovernmental Cooperation	M	H	H	H
Land Manipulation (grading, etc.)	L	H	L	H
Landscape Diversity	L	H	H	L
Siting of structures and/or related facilities	H	M	M	H

H=High; M=Medium; L=Low

•Based on size or scale considerations and/or probable proximity to population concentrations

MATRIX 2

NEGATIVE ECOLOGICAL IMPACT POTENTIAL

POTENTIAL IMPACT	DISPOSAL SYSTEMS			
	WATER	IRRIGATION	OVERLAND FLOW	FLOODING BASIN
Ecological Parameters:				
Energy flow	L	L	L	L
Nutrient Cycles	H	H	H	M
Hydrologic Cycle	M	H	M	M
Bioclimatic Responses:				
Speciation	M	H	M	L
Succession	M	H	M	L
Production/Respiration Ratio	H	H	M	L
Closure	H	H	M	M
Substrate and Media:				
Chemical Continuity	H	H	M	M
Physical Continuity	M	M	L	M
Ecosystem Stress, Long-run				
Geological changes	L	H	H	L
Climatic changes	L	L	L	L
Ecosystem Stress, Short-run				
Geologic changes	L	L	L	L
Land Flow	L	L	L	L
Erosion	L	L	L	L
Hydrologic cycles	M	H	M	M
Weather Changes	L	L	L	L
Microclimate changes	L	H	M	M

H=High; M=Medium; L=Low

Epidemiologic Input of Wastewater Management Program

Merrimac River Basin

July 13, 1971

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Recreational Use of Water and Disease - Most States have developed criteria for the sanitary quality of natural waters used for bathing. However, there has been considerable disagreement among various regulatory agencies on the precise microbiological standards that define permissible densities of total-coliform or fecal-coliform indicator organisms permissible if water is to be used for bathing. Most States require a sanitary survey in addition to other criteria, such as coliform counts. Some States have no coliform standards; such an absence of an upper coliform limit is consistent with a British epidemiologic investigation that concluded that there is a negligible health hazard associated with bathing in sewage-polluted marine waters in the absence of gross, visible fecal contamination.

Studies by Stevenson on Lake Michigan and the Ohio River showed that an epidemiologically detectable health effect in swimmers may begin at a level of total coliform contamination of approximately 2400/100 ml. Using an extrapolation of an average level of fecal coliforms of about 20% of the total coliform count, and reducing the 2400/100 ml value by half to produce a (unknown) "safety factor", an upper limit of a log mean of 200 fecal coliform/100 ml was developed for swimming (and an average level of 2000 fecal coliforms/100 ml for general recreational use) by the Federal Water Pollution Control Administration in 1968. However, Henderson has criticized these standards as too restrictive for a number of reasons. It is clear from an evaluation of available scientific literature on the relationships between swimming and disease that more data are needed to more precisely define the threshold level of microbial contamination that might result in disease in the general population associated with various forms of recreational water contact. Nonetheless, the standards cited above (FWPCA) seem reasonable as minimum permissible levels; and no evidence is presently available to indicate that these standards should be lowered.

Stevenson showed that swimmers have more illnesses than a comparable control group of non-swimmers. Eye, ear, nose, and throat disease represented more than half of the overall incidence in his studies, gastrointestinal disturbances about 20%, and skin and other illnesses the remainder. Since any large, natural body of water may be contaminated with almost any type of fecal microorganism from people, at least in theory any fecal-oral transmitted infection might result from oral contact with such contaminated water. In addition, diseases that have been associated with skin (or other) contact with water contaminated with microorganisms in the continental U.S. include: schistosome dermatitis, leptospirosis, tularemia, some tuberculous skin infections, and amoebic meningoencephalitis; the numbers of known cases of these diseases due to water contact is small.

Viral Hepatitis - Viral hepatitis may be transmitted by contaminated water, contaminated shellfish or other food or drink, person-to-person contact, the parenteral route, and through the air. However, viral hepatitis probably is most frequently transmitted as any other fecal-oral disease, by close personal contact. Special mention is made of hepatitis for two

reasons: first, techniques have not yet been developed to culture and study this virus in the laboratory, and, second, epidemiologic data available indicate that hepatitis viruses are unusually resistant to water-treatment processes. There have been a number of outbreaks of viral hepatitis associated with contaminated drinking water, some with chlorinated drinking water. Thus, the hazard of hepatitis associated with ingesting untreated, contaminated water during recreational activities such as swimming could be significant.

Fish and Shellfish - Shellfish harvested from polluted areas are capable of causing human disease, including typhoid fever, various enteric infections, and viral hepatitis. If standards that have been developed for use in shellfish sanitation are followed, including strict enforcement of prohibition of harvesting of shellfish from areas known to be polluted, the hazards of infection from shellfish are minimal. Diphyllobothriasis can be acquired by eating inadequately cooked, infected fish. Uncontaminated fish or shellfish can become contaminated with various microorganisms after harvesting, and this contamination can cause disease. And, there have been a number of reports of paralytic shellfish poisoning.

Irrigation with Sewage and Disease - Irrigation with sewage has been demonstrated to be a satisfactory method for reuse of effluents as well as a method to improve yields of plants. However, several possible health hazards may occur in the use of this practice. First, various human pathogens may survive in sewage, and contact with such sewage could cause disease if the pathogens were subsequently ingested. The hazards to health of ingesting fruit or vegetables commonly eaten raw that have either been grown with sewage-contaminated water or rinsed in such water are well known. Odors could result from sewage irrigation. Also, it is potentially possible for land irrigated by sewage to produce significant quantities of insects that might either be nuisances or might be capable of spreading disease. It is not known whether aerosols of sewage produced during irrigation would be hazardous to health; there probably is but a minor hazard to such aerosols, since there are no reports in technical literature proving that excess disease has occurred in individuals who continuously work at sewage treatment plants, where airborne microbial contamination from sewage does occur.

Beef or pork tapeworm infections in cattle or swine (which can be transmitted to man by uncooked, infected meat) can be acquired as a result of pasture irrigation with sewage effluents or by animals drinking contaminated irrigation water containing the parasites.

There should be no hazards to health, other than those discussed just above, of spreading sewage sludge on agricultural land. Sludge is commonly spread to dry (on sand beds) at or near sewage treatment plants.

Summary of Diseases that May Be Transmitted by Contaminated Water - A large number of diseases may result from various types of contact with water contaminated with microorganisms or other parasites, as is noted above and in a number of references in the bibliography below. In summary, these diseases in the U.S. include: infectious hepatitis; giardiasis, typhoid and paratyphoid fevers; salmonellosis; shigellosis; leptospirosis; amebiasis; "gastroenteritis" of unknown etiology due to microbial contamination, including viral contamination; echinococcosis; balantidiasis; schistosome dermatitis; tuberculous skin infections; and amoebic meningoencephalitis.

The dose of microbial (or parasitic) contamination, the virulence of pathogenicity of the organisms, the immune status (and other host characteristics) of those exposed, and other factors may influence the amount of infection and disease that results from human exposure to the contaminating organisms.

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THE MERRIMACK BASIN WASTEWATER MANAGEMENT PROGRAM:

Terrestrial Ecological Impact Considerations

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INTRODUCTION & OBJECTIVES

The objective of this report is to provide an indication of the ecological impact on terrestrial forms in the Merrimack River Watershed, should various alternative plans for wastewater disposal be implemented. Three of the seven alternative plans that are under consideration involve disposition of wastewaters by water treatment disposal methods. These three methods involve the construction of from three to eight sewage treatment plants of varying sizes, depending upon the method used. Should such plants be built, the terrestrial impact at any given site location should be minimal; certainly such treatment plants could be located, built, and landscaped with less impact than some of the gigantic shopping centers built with parking lots that exclude all forms of flora and fauna and cause microclimatic changes in temperature and rain run-off patterns. The collection and distribution facilities tied in with such treatment plants would presumably be underground; a minimal impact could be assured through the engineering and technological capacities of the Corps of Engineers.

This report, therefore, will treat the impact possibilities that could arise should one of the four alternative wastewater treatment schemes involving land disposal/usage be adopted. The four land disposal alternatives all involve irrigation and overland flow methods in varying degrees. The extent to which fauna and flora (for example) in the disposal areas and on a region-wide basis are favorably or adversely affected by applications of wastewater, therefore, will depend upon the greater or lesser intensity and amount of applications.

This report is divided into three broad areas of terrestrial concern: (1) microfauna; (2) macrofauna and flora; and (3) biogeochemical factors. Because many of the life forms in the physical environment and their biotic environment (i.e., their relationships to other living organisms) intertwine, some overlapping in the categories is inevitable. The synecological implications of this impact evaluation (i.e., the associations of organisms in relation to an area or habitat) complicates the evaluation and forces one to deal in more general terms. (It is easier, for example, to study individual organisms or a species in relation to a particular habitat.)

Finally, it should be noted that the physical and chemical environment must be examined in ecological studies. Qualitative and quantitative studies of plant and animal organisms can then be made, and the numbers of each species and their interrelationships determined. These processes have not been undertaken; even if they had, a "static" state could never be reached due to diurnal and seasonal changes that occur before any equilibrium is reached. There is a staggering dearth of environmental data (of all types) which must be obtained before firm conclusions can be reached regarding the long-range effects of wastewater land disposal systems.

MICROFAUNA

Habitat descriptions and impact implications

A microhabitat is a self-contained entity that is a miniature mirror of the biological balance of living organisms generally. Microhabitats include soils, plants, tree-trunks, logs, rocks, leaf litter, carcasses, dung, walls, caves, and nests of social insects. We will examine each habitat briefly and indicate some of the impacts that could result to them should wastewater irrigation/overland flow be initiated.

Soils. Soils are formed by the weathering of the parent rocks that comprise the crust of the earth, and this is the mineral substrate in which vegetation roots. In addition to the substrate, other soil components are dead organic matter, humus, water and air. There are generally three processes involved in the production of the parent material (i.e., through weathering):

(a) Mechanical weathering -- breakdown of the rocks occur without chemical changes;

(b) Chemical weathering -- chemical changes of the rock minerals occurs and new substances are created; and

(c) Biological weathering -- plants and animals cause changes.

Such weathering processes result in a soil profile, or characteristically layered soil arrangement. The resultant profile is mainly a function of the amount and kind of organic matter involved, and of the way in which water falling on the surface removes and redeposits the soluble components of the surface layers. In humid regimes, soluble salts are leached away; such leached soils are known as pedalfers and occur where rainfall exceeds potential evaporation. Under extremely heavy rates of overland flow in a wastewater management system, changes in soil types and even waterlogged horizons are possible. (A soil profile consists of various horizons, each

of which characterized by certain physical and chemical properties as described in Figure 1.) The surface layer of the soil usually consists of undecomposed material called litter (L) (sometimes "duff"). Under this layer is the humus layer composed of amorphous organic matter that has degenerated from its original structure; beneath the humus a varying number of "true" soil layers ("A" type) occur. The A_1 layer is a dark colored horizon with relatively high organic matter mixed with mineral fragments in it. This layer tends to be thick in grassy soils and thin in forests. The A_2 layer is often grayish in color and is the zone of maximum leaching. The "B" type horizons underneath the A layers are usually rich in iron compounds, clay, and humus and are usually dark. The "C" horizon is composed of parent material and finally grades into the "D" bedrock horizon.

Figure 1 which presents these soil horizons is typical of podsols (or acid) soils with a high acid hydrogen ion concentration (a pH of generally less than 5.5) and high drainage rates. Podsols develop on sandstones where fairly heavy rainfalls occur. Brown forest soils have profiles that are less uniform in color, and have a darker "A" humus layer. Such forest soils are generally acid, never base-saturated, and often develop on top of clays so that drainage is often poor. Excessive applications of irrigation wastewater on such forest soils could aggravate existing drainage conditions. In addition, there is the possibility that trees and plants on such highly acid soils could be poisoned if there were quantities of fluorine present in the wastewaters applied, through either natural entry of fluorides in the soils or fluoridated water from municipal and/or industrial sources.

L	Litter layer
A_o	Humus layer
A_1	Dark with high organic content
A_2	Light-colored, leached layer
A_3 & B_1	Transitional layer
B_2	Dark with maximum colloidal receipt
B_3	Transitional
C	Parent material
D	Bedrock

FIGURE 1. -- SOIL HORIZONS

The low pH mentioned above, which is probably typical of many of the forest soils in the Merrimack region, leads to a layer of litter that has low bacterial activity. The fungi in such litter break down cellulose but have little effect on lignin. The sources of the humus that is produced from such activity frequently are conifers. The nature and amount of organic litter in soil is mainly a function of the type of vegetative covering and the rate at which it decomposes. In alkaline (neutral) soils decomposition rates tend to be rapid due to bacterial and fungoid action which decompose both lignin and cellulose. In addition, the larger soil animals such as insects and earthworms aid in the mixing of humus with mineral particles. Such humus is typical of brown forest soils derived from broad-leafed trees.

Soil profiles also reflect conditions of surface relief, in addition to the rainfall and parent material from which they are derived. In hilly regions, shallow soils generally develop with concomitant high rates of run-off and erosion. Flat land areas generally have leached upper soils over-lain on a dense clay pan, due to little or no erosion in such areas.

Soil horizons that are waterlogged are generally gray-green or gray-blue in color, which indicates the presence of organic matter and anaerobic conditions. These soils often have a rusty-brown mottled appearance because of oxidized iron compounds. In such low-lying areas with poor drainage the accumulated humus may form peat, and in such anaerobic environments the organic remains of plants are generally just partially decomposed. The State of New Hampshire is a transitional region between the southern limits of the northern boreal forest, with which bogs are characteristically associated; and the northern limits of the eastern deciduous forest, which is a border zone that provides a favorable environment for the development of typical bog species. Such conditions pose questions regarding the

successional trends of both animal and plant communities. In addition to the theoretical ecological problems concerning bogs, the practical questions of bog contribution to groundwater supplies during droughts and their uniqueness and aesthetic possibilities as natural green belts for areas of high population densities are factors that should be researched before using bog complexes as part of wastewater disposal systems. The characteristics of bog ecosystems are given in Table 1. Should bogs eventually be used as part of a wastewater disposal system, discharges would probably have to be made only during the summer months in order to avoid flooding due to high water tables in the spring.

Plants. Terrestrial plants furnish innumerable microhabitats. Microfauna use plants for shelter and predators, evaporation, wind, temperature extremes, and other adverse conditions. Many species of spiders and insects inhabit flowers and seed pods, and many plants have symbiotic relationships with microfauna. Certain plant species have a wide variety of microfauna associated with them. A high transpiration rate from plant leaves often encourages small animals, as does high concentrations of calcium and other inorganic ions. The place in which a plant grows (e.g., sun or shade) can also influence the animals that are associated with it.

Favorable microclimates for certain animals are also created by the proximity of plants. Most species of mosquitoes, for example, congregate at different heights at different times of the day. Nearer the ground level, the air is moister but humidity gradients vary throughout the day so that the mosquitoes move up or down in order to remain in a fairly constant microenvironment. Irrigation spraying of wastewaters in forest areas could affect diurnal movement patterns of these insects, but the effect would probably be a minor one.

TABLE 1. -- CHARACTERISTICS OF BOG ECOSYSTEMS

Physiography:

(1) Blocked drainage causes an indefinite accumulation of organic materials; a small quantity of mineral soil is introduced by seepage, inwash, and atmospheric agents.
(2) Drainage is further congested by the growth of a bog. Several small bogs can therefore unite and modify the drainage pattern over a fairly large area. This process is reversed only in the late successional stages, when tree cover becomes extensive.
(3) Open water is invaded by a floating mat and pools are filled in from the top as well as from the bottom. Development is often cyclical.

Physical Conditions:

(1) The water table reaches the surface in the spring and is below the surface during the rest of the year. Quite often the phreatic level is just below the surface in the spring and considerably lower by mid-summer.
(2) The water surface is often discontinuous when it is above soil level.
(3) The adjacent open water is generally dystrophic (brownish).
(4) The substratum is cohesive, resilient, and can uphold considerable weight.
(5) The substratum is almost 100 percent organic and always in the form of peat with a low mineral content.
(6) A false bottom forms in open water, due to the accumulation of colloids.

Chemical Conditions:

(1) There is a predominantly strong acid reaction; the percentage of saturation is low.
(2) There is a large quantity of colloids in suspension.
(3) There is a deficiency of potassium and nitrogen in the soil, although there are some nitrogen-fixing bacteria.

Vegetation:

(1) There is often the presence of a floating mat usually dominated by ericoid plants.
(2) There is a physiognomic dominance of curvilinear contours, i.e., many-branched shrubs and cushion-like tufts or herbs and mosses.
(3) The bog can be viewed as a large cushion.
(4) There is dominance of the ericaceous types in many of the pioneer stages; and dominance of the needle-leaved types in the subclimax stages.
(5) Mosses (mostly Sphagnum) form the lowest layer.

Fauna:

(1) Animal life is scarce, both in number of species and of individuals. Snails are generally absent, while spiders and mites often quite abundant.

Tree trunks, rocks, and logs. Cracks and holes in trees and logs, and fissures in rocks provide shelter for many small animals, and very rich colonies of microfauna can be found under logs and rocks. Living and dead trees are habitats for wood-boring insects. The holes in trees often become filled with water and form breeding grounds for mosquitoes and other aquatic insects. When fungus decay occurs, such holes become larger and drier and become homes for fauna that usually inhabit rotten logs. Over time the tree may die, decay, and become a rotten log which continues to decompose, incorporating its material into the litter stratum of the forest.

As wood rots, the fauna changes as the various stages of decay occur. A succession of animal communities takes place, and each one is dependent on particular microinhabitants. A log can be examined at regular intervals and faunal successions observed throughout the decaying process. Such determinations should be undertaken on both control plots and wastewater spray-irrigated plots (such as the wastewater irrigation operations currently occurring at the Sunapee State Park in New Hampshire), in addition to microclimatic measurements of temperature, light, evaporation rates, soil moisture, light, and hydrogen ion concentrations (pH). With such data, extrapolations could then be made as to impacts on microfauna.

Leaf litter, carcasses, dung; walls, caves and nests of social insects. Leaflitter differs greatly depending upon the type of vegetation that produces it (which, conversely, is determined by the soil type). Litter gradually decays and becomes part of the soil humus; faunal and floral successions follow the decay process. Where litter covers are heavy, moisture is retained and temperatures tend to be equalized. There are many unique features of some of the animals inhabiting litter. Certain species of mites, for example, will inhabit spruce needle litter for entire generations.

In the microhabitats created by carcasses and dung, primary faunal successions typically occur, in contrast to secondary successions which are more common and generally take place due to changes in vegetative cover. A predictable succession of blowflies, their maggots, beetles predatory upon the maggots, wasps, flies, gnats, and other insects visit carcasses; any given succession is dependent upon the location of the carcass (i.e., a dry or wet locale and the amount of sunlight or shade). Depending upon the volume of wastewater, faunal successions could be affected; this would also be true of faunal colonies in manure deposited by cows, sheep, horses or other livestock where overland wastewater flow through pastures and meadows occurred. Animal manures are subjected to varying stages of decomposition, usually in conjunction with a progressive water loss, until they eventually are absorbed into the soil humus. Again, the lack of data on such successions in the Merrimack region prohibits a definitive prediction and one can only suggest that the faunal successions would probably be altered; other forms compatable with moister conditions would probably enter into the decomposition sequence.

In the case of walls and caves, the microhabitats contrast sharply to those previously described. Such habitats exhibit seasonal changes, but do not have the faunal successions described above or a vegetative food base. Such habitats are generally dry, do not have a wide variety of microfauna, and probably would not be affected by wastewater applications.

Social insect colonies, such as ants, bees, and wasps are very specialized microhabitats. Many of these forms have unique methods of preserving the microclimate of their nests. Bees, for example, regulate the temperature of their hives by bringing water to the colony, fan with their wings, and drive the air (which is cooled by evaporation) through the combs. In severe cold, the bees run through the hive which increases their metabolic rates and consequently warms their bodies. Should such social insect forms be adversely affected, it would probably occur through any extensive use of spray irrigation methods.

MACROFAUNA AND FLORA

Habitat descriptions and impact implications

Forest and agricultural lands. The central and southern areas of New Hampshire are generally hilly. The area has been described as a rolling dissected plateau, with occassional peaks that rise and dominate the landscape. The country has an uneven, "hummocked" appearance that is characteristic of glaciated regions, and a blanket of glacial till, thinnest on the mountains in northern reaches. There are several hundred lakes and ponds, which resulted from glacial modification; level meadows, swamps, and bogs occur in the drained basins of drift-dammed lakes.

Soils in the basin (and state) are mainly granitic in origin -- very stony and acid. Agricultural productivity is limited by topography, stones, bedrock depth, and the rapid depletion of humus and nutrients that occurs with cultivation of the typical podzolic forest soils we have previously described. The greatest amount of intensive agriculture in the Basin occurs in the southern portion of the Merrimack in the stretch between Concord and Nashua. Extensive vegetable farming occurs in that area, and water from the Merrimack River is one source of irrigation for these crops.

Roughly 87 percent of the land area in New Hampshire is in woodland. There is a fairly broad distribution of the four main tree species: pine; spruce and fir; maple, birch, and beech; aspen and birch. The southern portion of the Basin has large stands of white, red, and pitch pine. Moving north, extensive stands of spruce, fir, aspen, and birch are situated in the far northern areas.

Forests and forest products are, in one sense, the most available resources in New Hampshire. However, in many respects, forests are comparatively sterile in terms of wildlife production, unless proper cutting and management practices are followed. Many hunters have seen the clearing of forested land occur (through intentional or accidental means), with a subsequent tremendous spurt in game populations over subsequent years. With the removal of the trees, the undergrowth is exposed to light and air; food sources for deer, grouse, woodcock and other species become available. New Hampshire forests have been generally subjected to highgraded cutting practices. As a result, low grade pole hardwood stands abound that have both low forest productivity and wildlife potential. Many of these forest areas are situated on deep loamy soils, quite accessible for forest management.

In terms of an overall environmental impact on macrofauna, wastewater discharges could be extremely beneficial if managed properly. This observation is equally valid in terms of the forest resources of the region, if appropriate forest management practices were adopted. Historically, New Hampshire has passed through the period of high wildlife populations, i.e., that period associated with abandoned fields, pastures, and a highly mixed environment. Wildlife abundance (or the lack of it) stems from the plant successional stages available. The macrofauna of New Hampshire were typically those of early succession, and of early succession forests, with the exception of turkeys and squirrels which are animals of more mature forests (hardwoods). Since the decline of land areas in pastures and fields (due to construction and the highgraded cutting practices previously noted), the deer, hare, rabbit, grouse and woodcock populations have been declining. This is also true of a wide variety of small animals and song birds associated with such habitats. In general, big game species, furbearers, predators,

small game, and most bird species would probably be benefited by improved habitat conditions were wastewater management combined with appropriate forestry and land management. Overland flow application of wastewater, for example, implies some management of forest, field and meadow areas involved. Rejuvenation and management of such areas could be combined with wastewater system maintenance at small incremental costs.

The future of forestry in New Hampshire lies with fast-growing species on accessible fertile soils. Wastewater would be a positive factor in terms of both quantity and quality of wood products. The potential for an integrated wastewater disposal system with combined forestry, land and wildlife management is very great.

For example, if aspen forests were planted, several possibilities arise:

1. Aspen is an excellent species for wildlife production and relatively easy from a management standpoint. Aspen is the key to the sustenance of ruffled grouse populations. Other species such as woodcock, deer, and cottontail rabbits are also exceedingly favored by aspen forests.

2. Aspens provide fast fiber production for pulp purposes. Maximum tree growth is attained in 40 years; 40-year rotations (i.e., clear-cut portions every 10 years) will yield a six percent return on an investment.

3. If wastewater irrigation were initiated on aspen stands, applications could probably begin quite early in the spring (i.e., assuming a combination land disposal system in summer and P.C. plants in winter), since the green inner bark of aspen photosynthesizes successfully before the trees leaf out. In addition, applications could continue to be made late into the fall months for the same reason (continued high photosynthesis after leaf drop). Further reinforcement stems from the fact that aspens will grow well on very wet soils. Other trees that are highly water-tolerant include willows, cottonwoods, and maples.

4. The whitetail deer is probably the most important big game species in New Hampshire. Deer are not affected generally by the level of management undertaken; the primary controlling factor in deer population levels at the present time is the amount of hunting pressure exerted. In those areas sustaining deer, a square mile supports about six deer. Deer feed primarily around the edge of forest areas. If increased productivity in forests occurred due to irrigation spraying of wastewater, they might browse in the forests. More significantly, if portions of forested land were cut back to accommodate the installation of irrigation pipes and relay pumps, the habitat potential would be improved because of greater fertility and growth. One square mile can sustain around 15 head of deer; that is, more than twice the current rate. If, in addition, a vigorous forest management program were initiated, the potential faunal production and economic impact are very great.

If wastewaters were applied in large quantities to pitch pine and red pine stands, these species might be adversely affected. Excessive wastewater could cause spurts in vegetative growth in these species with concomitant low root growth and lack of support. The trees might suffer high rates of windthrow.

On stands of cottonwoods, red maple, poplar and aspen, there is some indication from wood physiologists that summer growth (which presumably would be enhanced through wastewater applications) leads to higher quality wood than the usual spring growth contributes.

In summary, the benefits to wildlife and forestry should be quite great through wastewater applications: good successional patterns, open areas, fertilization, water availability (with more permanent stream flows), shorter rotations, and more valuable and interspersed species. Enhanced recreational opportunities would be one benefit available to the public.

Lagoons and bogs. Large lagoon installations for land disposal systems in the Basin probably would create one of the major terrestrial impacts. The most significant factor is the amount of acreage that would be taken out of production. Generally, open fields are the areas chosen for such lagoons, because of their accessibility and the minimal cost required to develop such areas. The City of Rochester, New Hampshire has developed a very large lagoon system which required some 250-300 acres. The system, in brief, consists of a settling basin for solids, and effluent in the lagoons is subjected to bacterial action. "Clean" water is skimmed off into another lagoon series, and the waters are finally discharged into the Cocheco River. Studies of systems such as this should be undertaken to determine short- and long-range impacts. The possibility of using lagoon areas in conjunction with some commercial enterprise(s) should be explored. For example, a technique called algae stripping is currently being investigated in California. Algae is grown and harvested under controlled conditions. Water purification and a salable crop are possible; it is estimated that a daily flow of 700,000,000 gallons of agricultural drainage waters can produce $9,000 worth of dried algae. A potential market exists in the livestock and poultry industries; the algae is a possible substitute for fish meal.

Various waterfowl species, such as black ducks, flock to lagoon areas to feed. Several specimens of this species were obtained last year, and subjected to laboratory analysis. High rates of enteritis contamination were observed. The possibility of spreading disease organisms through the migratory activities of waterfowl should be evaluated through further research.

We have previously mentioned the possibility of using bogs as components of wastewater disposal systems. Bogs could, in fact, be natural lagoons if managed properly. Very little work has been done on a regional level with regard to edaphic factors in bogs (i.e., correlating organic soil characteristics with natural vegetational associations). Enrichment of a test bog area through wastewater applications should be initiated. Bogs typically support some 30 to 40 floral species (plants and trees); faunal species are also generally low in diversity. A much more productive environment through wastewater enrichment, combined with "natural" lagooning, is a possibility.

Other flora possibilities

The reclamation of spoils bank materials through irrigation with sewage effluent and sludge has been tried experimentally at Pennsylvania State University. The preliminary results are most encouraging. In many areas of southern New Hampshire, unsightly and unproductive areas exist because of sand and gravel removal. Test sites should be initiated to determine the most adaptive species to such environments; the best combinations of effluent and sludge; the ability of such depleted areas to regenerate; and the nature of the water resulting from such reclamation. The economic, aesthetic, and biogeochemical possibilities are promising and intriguing.

BIOGEOCHEMICAL FACTORS

There are three primary areas of concern with regard to possible biogeochemical impacts: (1) The renovation of the effluent wastewater applied to the soil; (2) The recharge rates of the renovated wastewater; and (3) The ultimate effect on the quality of groundwater in the region.

Renovation of effluent wastewater

The initial consideration in determining renovation processes is the composition of the effluent that will be discharged into the biogeochemical environment. Presumably, little or no alkyl benzene sulfonate (ABS or surfactants which cause foam) would be discharged, since this surfactant has been banned since 1965. (However, linear alkylate sulfonate or LAS, which biodegrades more effectively than ABS, is now used by detergent manufacturers. The fate of LAS in soils is not well researched.)

It is probable that fairly effective removal of most effluent pollution components could be expected before the water is recharged into groundwater. With application rates of one to two inches of wastewater per week, nitrogen and phosphorus concentrations would be reduced -- filtering through the upper twelve inches of forest soil -- by roughly 70 percent in the case of nitrate nitrogen and 90 percent in phosphorus levels. Organic nitrogen would probably be removed on the order of 75 percent. The removal of potassium, calcium, and magnesium constituents would probably range from 75 to 90 percent. Sodium removal would probably not be as high, especially on stands of pine; 30 to 40 percent sodium removal might occur, with somewhat higher percentages possible on hardwood stands. If the combination land and water disposal system were employed (i.e., P.C. in winter and land disposal in summer), the forest soils would probably be able to perform at comparable renovation rates

over the years. There is the possibility, however, of build-ups in concentrations of nitrate nitrogen and sodium over time. Monitoring a test situation, such as the current operations at Sunapee, New Hampshire, could provide necessary parameters.

Recharge rates of renovated wastewater

The rate at which a soil absorbs the effluent is critical in the operation of the disposal systems. It does not seem likely that wastewaters applied on Gloucester and Paxton soils, at the rate of one to two inches per week, would drain through too rapidly so as to cause contamination of groundwaters. Given the infiltration and percolation conditions previously discussed, the proportion of wastewaters actually reaching the water table will depend mainly on the relationship of rainfall intensity, infiltration capacity, and the extent of soil moisture deficit. Proper management should preclude irrigation or flow operations when periods of heavy precipitation occur in any given area. Given an overall evapotranspiration rate of 20 to 40 percent, roughly 60 to 80 percent of wastewater applications could be expected to find its way into the groundwater in the region.

Forest litter itself can be expected to intercept a large amount of the wastewater applications. Maximum available water storage of the litter in some pine and spruce-fir forests is estimated at 100 to 115 percent. At these rates, maximum available storage of water would range from 0.3 to 0.4 inches of water. Multiplying these factors by the number of acres in the Merrimack Basin, allowing for variations in litter weight according to the type of forest cover, would give an estimate of the amount of wastewater that would be evaporated from litter.

One other consideration is pertinent: if the rate of wastewater application in any given instance were to exceed the percolation rate for water away from the root zones of the forest or vegetative cover, the build-up of a zone of saturation is possible. Such a build-up would eventually encompass the roots of larger plants (see Figure 2) to the exclusion of aeration processes. Proper management should forestall this problem.

Quality of the groundwater

Groundwater in the Basin (and State) is generally of good chemical quality at the present time. Hardness is an occassional problem, along with frequent corrosion from iron. Groundwater use has been increasing over the years, as small towns in the lower reaches of the Merrimack continue to grow due to suburban home construction.

Groundwater is obtained from bedrock and glacial drift; yields from bedrock generally provide adequate water for domestic uses and small towns, and glacial drift water yields are relatively small in upland areas and moderate in lowlands.

There is a very wide range in average well depths and yields in the Merrimack Basin. In Hillsboro County, for example, well depths range from 12 to 219 feet and yields range from less than 5 to 13 gallons per minute.

According to the New Hampshire State Geologist, discharge of wastewaters would probably not affect groundwater quality significantly, given the proposed application rates of one to two inches per week under summer conditions. Test wells in the areas of wastewater discharge should be initiated prior to and during wastewater applications.

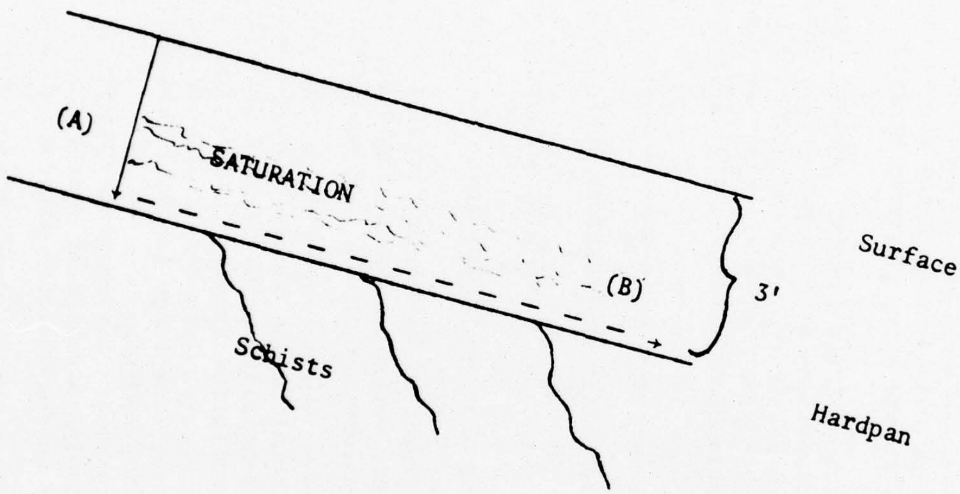

FIGURE 2. -- Theoretical flow and saturation possibilities of excessive wastewater application. Should the rate of flow (A) exceed that of (B), a zone of saturation could result.

TABLE 2. -- Summary of possible terrestrial impacts utilizing only land disposal methods for wastewater in the Merrimack Basin (on a year-round basis).

CATEGORY	IMPACT
MICROFAUNA	(1) Possible fall in reproductive rates due to adverse conditioning of the environment with excretory products applied continuously in large quantities. (2) Extreme effects of trace elements unknown, but possible danger from excessive applications of elements (e.g., fluorides). (3) Marked changes possible in humidity responses of several species (e.g., mosquitoes, millipedes) with resultant seasonal and diurnal consequences. (4) Food chain disruptions possible; biological structure of community could be altered.
MACROFAUNA AND FLORA Forest and agricultural lands	(1) Year-round wastewater applications could lead to saturation of root zones in some areas. (2) Forest species such as pitch pine and red pine could be affected adversely. (3) Forest species that are highly water-tolerant (e.g., aspens, willows) would probably thrive. (4) Significant growth of herbaceous vegetation in pastures and meadows would probably occur. Browse areas for deer and certain bird species would be diminished, unless forest and land management practices compensate.
Lagoons and bogs	(1) Major terrestrial impact caused by large amounts of acreage necessary for lagoons. Essentially would displace all wildlife and other biological forms in installation areas. (Large coveys of game birds in the Rochester, N.H. area were completely extirpated.) (2) Possible sepsis from large lagoons; waterfowl a possible disease vector through feeding habits. (3) Wastewater generated during winter months could cause flooding in bogs when water tables are high in spring. (4) Major impact on successional patterns in bogs possible.
Other flora	(1) Major successional changes possible. Wildflowers and shrubs partial to dry soils and conditions affected.

TABLE 2. -- Continued

CATEGORY	IMPACT
BIOGEOCHEMICAL Renovation	(1) Possible build-up and overloading of nitrate nitrogen and sodium in relatively short time period.
Recharge	(1) Contamination possible due to decreasing rate of effluent absorption on heavily irrigated soils. (2) Decreasing efficiency of forest litter interception of wastewaters possible.
Quality of groundwater	(1) Higher possibility of wastewater intrusion into wells.

TABLE 3. -- Summary of possible terrestrial impacts utilizing combination land and water disposal methods (e.g., P.C. in winter, land in summer) for wastewater in the Merrimack Basin, with accompanying forestry and land management.

CATEGORY	IMPACT
MICROFAUNA	(1) Less likelihood of affecting reproductive patterns. Possible habitat enrichment for many species. (2) Effects of trace elements uncertain, but probably minimal. (3) Some fluctuations in humidity responses of certain insects; probably more impact on short-run diurnal patterns rather than long-term seasonal patterns. (4) Some alteration of food chain possible; minimal effects probable.
MACROFAUNA AND FLORA Forest and agricultural lands	(1) Saturation of root zones unlikely with applications geared to precipitation conditions. (2) Highly beneficial effects on forest stands of aspen, willow, maples, etc. Irrigation installation in combination with clearing practices would enhance wildlife diversity and frequency. (3) High beneficial potential for forest pulp and wood products industry. (4) Controlled applications on less water-tolerant forest species (e.g., pine) would prevent loss.
Bogs	(1) Use as natural lagoons could enhance flora and fauna. Controlled storage would preclude spring flooding. (2) Initiation of early successional patterns possible.
Other flora	(1) Reclamation of mined-out sand and gravel beds possible.

TABLE 3. -- Continued

CATEGORY	IMPACT
BIOGEOCHEMICAL Renovation	(1) Effective renovation of most effluent pollution components probable. (2) Some possible build-up over years of nitrate nitrogen and sodium. Short-range effects not severe; monitoring of areas would have to be initiated.
Recharge	(1) Contamination due to rapid drainage unlikely. Probable return of 60-80 percent of renovated wastewater to groundwaters. (2) High rates of litter interception, with subsequent evaporation.
Quality of Groundwater	(1) No significant impact on groundwater quality. Test well installations in disposal areas recommended.

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Ocean Disposal of Sanitary Wastes

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1.0 Introduction and objectives

The objective of this report is to provide an introduction to waste disposal at sea as transported: 1) directly by ocean outfall pipe and 2) by barge or ship transport. The types of solid and liquid wastes to be considered are those resulting from the various types of sewage treatment, both traditional and advanced. Emphasis will be given to ocean outfall site selection, to environmental impact, and to the effects of heavy metals, pathogenic organisms, and persistent substances as they relate to the food chain.

2.0 Factors to be considered in site selection

2.1 The character of the ocean environment

The waters of the oceans are the most complex solutions known. In trace amounts all naturally occurring elements may be found in the oceans. Ocean water is comprised of a solution of organic and inorganic substances. The inorganic salts of the oceans have presumably been derived from volcanic activity and from erosion of the earth's crust. Meteoritic material may also have contributed to the salts of the sea. The organic materials in the sea have been formed as products of decomposition of its immense amount of life. These processes have continued since the formation of the earth; however, most evidence supports the hypothesis that the oceans were formed early in geologic history and have changed little with respect to composition since they were formed. Since the dawn of recorded history, both inorganic and organic contributions related to man's activity have found their way to the sea. It is only

in relatively recent times that the earth's coastal population density has become so great that the ultimate disposal of sanitary wastes has become of such a magnitude that it is reasonable to expect changes in the coastal regions of the ocean. Coastal areas of the ocean are defined to include that region of the ocean floor extending from the coast to the two hundred meter depth contour. This depth zone of the ocean, called the continental shelf, includes 7.6 percent of the ocean area (including adjacent seas), varies from zero to eight hundred miles in width, and its average width for the world ocean is thirty miles.

Seaward from the continental shelf is a depth zone of steeper grade called the continental slope which extends from the two hundred meter contour to the three thousand meter contour. For economic reasons, almost all dumping of sludge and all ocean outfalls are relegated to the continental shelf. Off major rivers, the continental shelf is parted by submarine canyons which cross the shelf, often extending seaward to the continental slope. These canyons have been used as a means of waste disposal; however, more study is needed to determine whether or not this practice is harmful or has any far-reaching effects.

The salt content (salinity) of the ocean is its most readily apparent property. The salinity of the ocean is important in that the salinity, temperature, and to a lesser degree, pressure, affect the density of sea water. Thus an effluent introduced to the ocean will sink, remain at a neutrally buoyant depth, or rise to the surface, depending on its density relative to the density of the sea water to which it is introduced. Salinity has been defined as the total amount of solid

material in grams contained in one kilogram of sea water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized. Thus salinity is a measure of the dissolved solids in sea water although its numerical value is slightly less. An interesting property of sea water is that the ratios of the major ionic constituents of sea water to one another are very nearly constant. Thus salinity may be determined operationally by chemical analysis of one constituent or by measurements of electrical conductivity of the sample.

The salinity (in parts per thousand) of sea water is operationally defined by the equation:

> Salinity = 0.03 + 1.805 x Chlorinity, where the chlorinity is defined as the total amount of chlorine, bromine, and iodine in grams contained in one kilogram of sea water, assuming that the bromine and the iodine had been replaced by chlorine.

The most abundant elements in sea water are listed in Table 2-1. Only the top fourteen measurably affect the density. The salinity can vary from just under thirty parts per thousand in coastal waters to more than thirty-six parts per thousand in the North Atlantic. The specific gravity of surface sea water (numerically identical to density by definition) varies from about 1.021 to about 1.029 for various combinations of salinities and temperatures. An important salinity-dependent characteristic of sea water is its freezing point. At a salinity of 24.70 parts per thousand the temperature of maximum density occurs at the freezing point, $-1.332°$ C. Thus the density stratification that occurs in fresh water lakes cannot occur in the ocean. The average or typical den-

Table 2-1

The 42 Most Abundant Elements In
Sea Water, In Percent By Weight*

Oxygen	85.89	Barium	1×10^{-6}
Hydrogen	10.82	Zinc	5×10^{-7}
Chlorine	1.90	Manganese	5×10^{-7}
Sodium	1.06	Lead	4×10^{-7}
Magnesium	0.13	Iron	2×10^{-7}
Sulphur	0.088	Cesium	2×10^{-7}
Calcium	0.040	Uranium	1.5×10^{-7}
Potassium	0.038	Selenium	1×10^{-7}
Bromine	6.5×10^{-3}	Thorium	5×10^{-8}
Carbon	2.8×10^{-3}	Molybdenum	5×10^{-8}
Strontium	1.3×10^{-3}	Cerium	4×10^{-8}
Boron	4.8×10^{-4}	Silver	3×10^{-8}
Silicon	2×10^{-4}	Vanadium	3×10^{-8}
Fluorine	1.4×10^{-4}	Lanthanum	3×10^{-8}
Nitrogen	$0.3\text{-}7 \times 10^{-5}$	Yttrium	3×10^{-8}
Rubidium	2×10^{-5}	Copper	2×10^{-8}
Lithium	1.2×10^{-5}	Nickel	1×10^{-8}
Aluminum	1×10^{-5}	Scandium	4×10^{-9}
Phosphorous	5×10^{-6}	Mercury	3×10^{-9}
Iodine	5×10^{-6}	Gold	4×10^{-10}
Arsenic	1.5×10^{-6}	Radium	7×10^{-15}

* V.M. Goldschmidt, 1954, p. 49, Geochemistry, Oxford: Clarendon Press.

sity of sea water is usually taken to be about 1.025 grams per cubic centimeter.

Oxygen is essential to many of the biological processes that occur in the sea as it is in fresh water. In the temperate zones of the North Atlantic, oxygen concentrations in upper layers of the water vary from less than 6.5 ml per liter to more than 7.0 ml per liter; however, local conditions and seasonal fluctuations can cause considerable variations, especially in coastal regions.

Major chemical cycles in the oceans include: the carbon dioxide system, the phosphorus cycle, and the nitrogen cycle. Sea water contains carbon dioxide as bi-carbonate and carbonate ions, as undissociated molecules of CO_2 and as carbonic acid, all in equilibrium with each other and with hydrogen ions present. The phosphorus cycle is complex. It is affected by runoff (15×10^6 metric tons per year); it is affected by currents and on a larger scale by regions of upwelling and vertical mixing which return some of the phosphorus to portions of the water column where it is again available to biological activity. In the sea, phosphorus occurs principally as inorganic orthophosphate. In the euphotic zone of warm sunlit regions, orthosphosphate can be nearly depleted. In deeper, colder waters about as much phosphate as is introduced by the total river inflow precipates as apatite. Phosphorus does occur in some soluble organic forms, however their chemical composition is not well known. The nitrogen cycle, in the sea, is perhaps more complex than the phosphorus cycle. Nitrogen exists as molecular nitrogen, in organic forms, ammonium ions, nitrate, nitrite, and other oxides of nitrogen.

Soluble organic material (those materials which can pass through a 0.45 micron filter) are: A source of energy for algae, bacteria, and invertebrates; growth stimulators, such as vitamin B_{12}, thiamine, and auxins; and perhaps growth inhibitors for some species. Finally, they may serve as complexing materials for trace elements.

Thus the ocean is a complex system made up of numerous integrating systems--physical, chemical, and biological. There is evidence that the ocean has been in its present stable dynamic equilibrium for a long period of geologic history. As a consequence of this stable environment, its inhabitants are not tolerant to great change as are many of the terrestrial inhabitants of the earth. Thus we must carefully consider the effects of our waste disposal activities in the sea.

2.2 Circulation in the Coastal Zone

Waste disposal problems off the coast of the Eastern megalopolis are different from the presumably less difficult problems of waste disposal off the California Coast. This is in part due to the proximity of deep water to the California Coast where disposal of liquid sanitary waste and sludge by ocean outfall is primarily a problem of diffusor design and initial dilution requirements. There is some concern that eventually there will be so many outfalls that a strip of affected bottom may become continuous between the outfalls; however, to date the affected regions near ocean outfalls remain local in extent. Thus the discussion of the coastal circulation which follows has been restricted to apply to the Eastern Seaboard of the United States.

There are many scales of motion in the coastal zone. Motions range from molecular motion at one end of the scale to general ocean circulation at the other. The distinction between advective processes and non-advective processes depends on the scale of motion of interest. Motions that are of the scale of the continental shelf and are at least of seasonal duration can be conveniently considered to be mean motion. Tidal motion and other smaller scale motions may be considered to be diffusive in nature. The driving force for circulation in the coastal zone is similar in some respects to the driving force set up by the density differences which drive the net non-tidal circulation in estuaries.

The density difference is brought about by dilution of the sea water by river inflow to the coastal zone. This less saline and therefore less dense surface water sets up density gradients across the shelf resulting in an outward circulation at the surface and an inward (toward the coast) circulation at depth. Another important factor is the effect of the earth's rotation. The Coriolis force acts to deflect the offshore (surface) current to the right in the Northern Hemisphere. Circulation is thus counter-clockwise in a bay and clockwise around a bank or point. The surface water must, for reasons of continuity, at least equal the river inflow; however, since the salinity increases with depth in almost all coastal regions, the continuity of salt must also be considered. When this is taken into account it is estimated that the net offshore transport of surface water may be on the order of fifteen to twenty times the total river inflow for the region. U.S. Geological Survey records indicate that in temperate zones in the Northern Hemisphere maximum river runoff is concentrated in March, April and May; thus the coastal

currents follow a seasonal cycle related to the seasonal supply of fresh water to maintain the density gradients which drive the circulation. This circulation pattern can be and often is modified by the effects of wind stress on the ocean surface. Offshore winds move the surface water away from the shore and since this water must be replaced, it is replaced by denser, colder water from below. This phenomena is called upwelling. Onshore winds reverse this modification to the density driven circulation pattern (downwelling). The wind stress brought about by an offshore wind balances, in quasi-steady state, the pressure gradients brought about by the upwelling. When the wind abruptly stops after having blown for a sufficient length of time (several days), the pressure gradients remain with no support. Thus the equilibrium must readjust, and the denser water sinks and flows offshore and is replaced by an onshore flow of surface water. This effect has considerable bearing on any material in the surface water since it must move directly to the shore line. Table 2-2 lists estimated flushing times for the continental shelf between Cape Cod and Chesapeake Bay.

Diffusion in the ocean has usually been described by the Fickian model:

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x}\left(k \frac{\partial c}{\partial x}\right)$$

c = waste concentration

x = space coordinate

k = eddy diffusivity coordinate.

In two dimensions, for a unit area in the plume, using continuity concepts, and including advection, this equation becomes:

$$\frac{\partial c}{\partial t} + v_x \frac{\partial c}{\partial x} + v_y \frac{\partial c}{\partial y} = k\left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2}\right) - ac$$

Table 2-2

Flushing Times of the Continental Shelf between Cape Cod and Chesapeake Bay for an Average River Flow of 14.5×10^9 ft^3/Day[a].

	Flushing Time, Days		
Depth Range, Fathoms	April-June	July-Sept.	Oct.-March
0-20	112	125	108
20-30	127	156	130
30-40	119	157	123
40-50	62	83	62
50-100	52	91	56

[a]Data from Ketchum and Keen, 1955.

These flushing times were estimated from the mean residence times, defined as the ratio of the total volume of river water accumulated on the continental shelf to the rate of river inflow. This estimate agrees fairly well with an estimate based on an analysis of all available tracer experiments made on the continental shelf.

v_x, v_y are velocities in x and y, and a is a first order decay constant. Solutions for these equations have been found for various boundary conditions. In the ocean the major difficulty is related to the uncertainty of the scale of the phenomena in question and to the variation in space and time of k, the diffusion coefficient. Okubo (1962) has summarized the power laws which have been used to describe varying turbulent diffusion coefficients.

The action of the tides is primarily to produce the energy for the processes of turbulent diffusion. Offshore tidal currents are rotary in nature. A time history of the tidal current vector typical of the semidiurnal tides off the eastern coast of the United States describes an elipse. In restricted regions near shore, reversing tidal currents occur which may act to deposit aesthetically unpleasing materials on shore.

2.3 Outfall site selection

Outfall site selection must be done on a case-by-case basis. The information necessary to design an outfall that produces the least damaging effect possible on the environment and at the same time is economic must include:

1) the various types of effluent characteristics including possible concentrations of toxic substances.
2) impact on beneficial uses and on public health.
3) impact on the marine environment.
4) the development of the necessary criteria to protect or reduce the impacts in 2 and 3 above.
5) the oceanographic characteristics of the outfall sites.

6) waste dispersion, including initial diffusion, waste transport (advection), and decay of non-conservative substances.

Oceanographic information must be obtained from specific field programs as well as from theoretical considerations. The following criteria should be investigated as part of the design of an ocean outfall site:

general water circulation
meteorological effects on currents
surface and subsurface currents
effects of waves, surges, tides, and littoral drift
diffusion characteristics
density structure, temperature, and salinity
submarine geology and topography
mutual proximity of proposed or existing outfall sites.

Attention must also be given to the problem of floatable solids. A major outfall in Rio de Janeiro was found to need an outfall over four times the length of that required to meet coliform standards equivalent to those of California because of the dilution requirements for floatable solids. (Ludwig et al, 1964).

Investigations of liquid effluents should be oriented heavily toward studies of dispersion, diffusion, and decay of nonconservative substances. Studies related to sludge disposal by outfall must concentrate on the effects of possible toxic substances and on the effects of the physical impact of the sludge on the benthic community.

Economic studies of outfalls have weighed the cost of various degrees of treatment against the cost of long pipelines to sea which often must include the cost of

pumping. Important long ocean outfalls are listed in Table 2-3. Figure 2-1 illustrates an approach (from Pearson, 1955) toward an economic analysis of an outfall pipeline. The economics have since changed, and new techniques have been discovered, so these figures no longer apply; however, an analysis of a similar nature should be made as part of the trade offs of this type of waste disposal system.

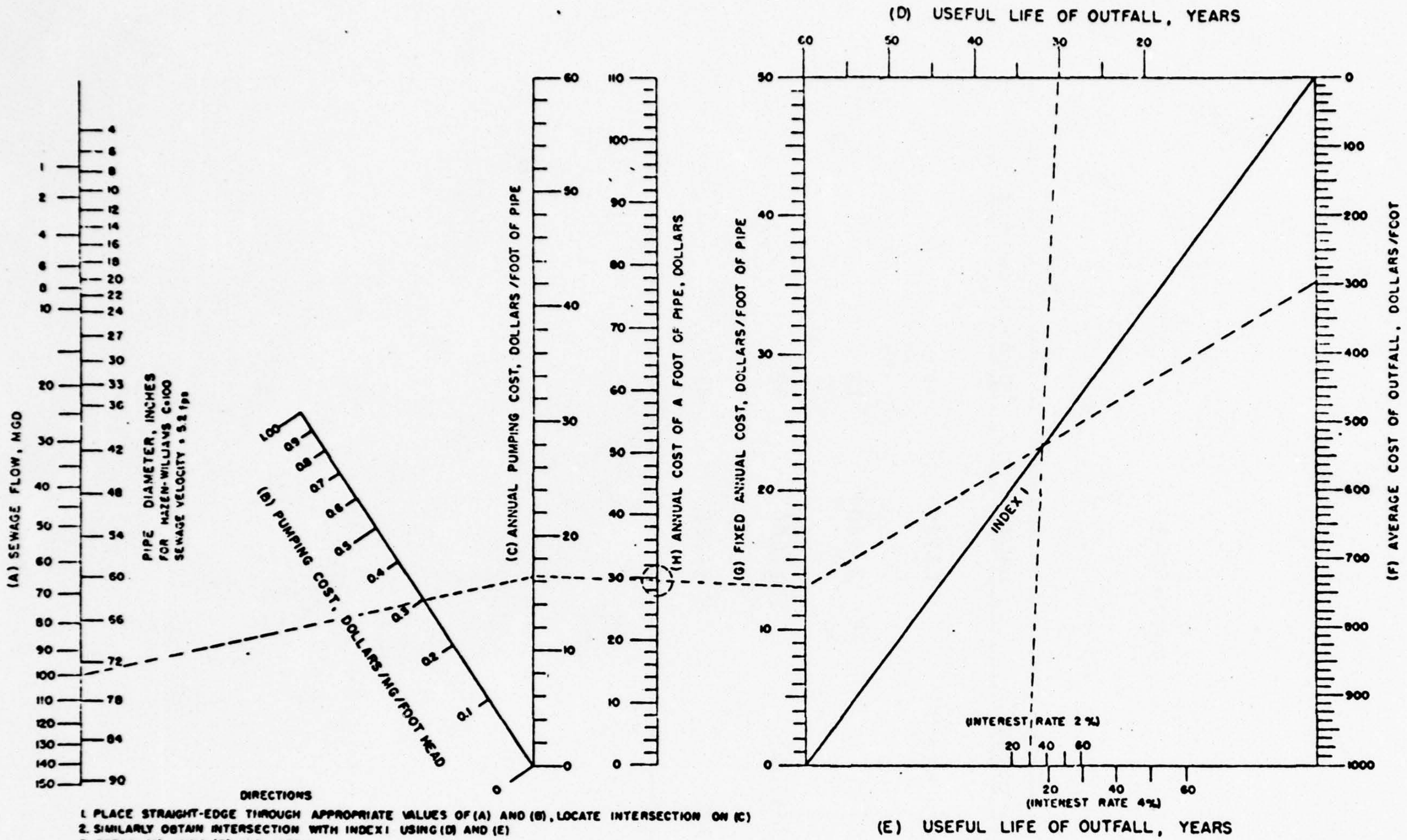
2.4 Offshore dumping site selection.

The most important oceanographic aspects to be considered in offshore dumping site selection are ocean currents, oxygen depletion, and economic resources. Figure 2-2 (Ketchum, 1970), shows the dumping area in the New York Bight. The same knowledge of oceanographic conditions needed to evaluate ocean outfalls is needed to evaluate sludge dumping areas. Emphasis must be placed on changes in the benthic community and on oxygen depletion in the consideration of dumping sites. The ocean is resilient, it can absorb large quantities of waste. When the limit is finally exceeded, it is possible that drastic changes could occur. This is apparently what has happened in the New York Bight. Table 2-4 indicates by type the amounts of material dumped in the ocean.

The New York Bight dumping area, according to Horn, et al, 1971, may be expected to have had an impact on both commercial and sport fin and shellfisheries as well as on potential marine resources. Horn, et al also believe that dumping in the New York Bight area is a potential threat to recreational use. It may be noted here that a potential expense related to dumping may be regulation and control. Short dumping is alleged to have occurred in some regions. This is not too surprising, if true,

Table 2-3

Location	Length and Depth in meters	
Virginia Key (Miami)	1,370	6
Miami Beach	2,140	12
Hyperion (design)	11,000	92
Hyperion 1957	8,000	61



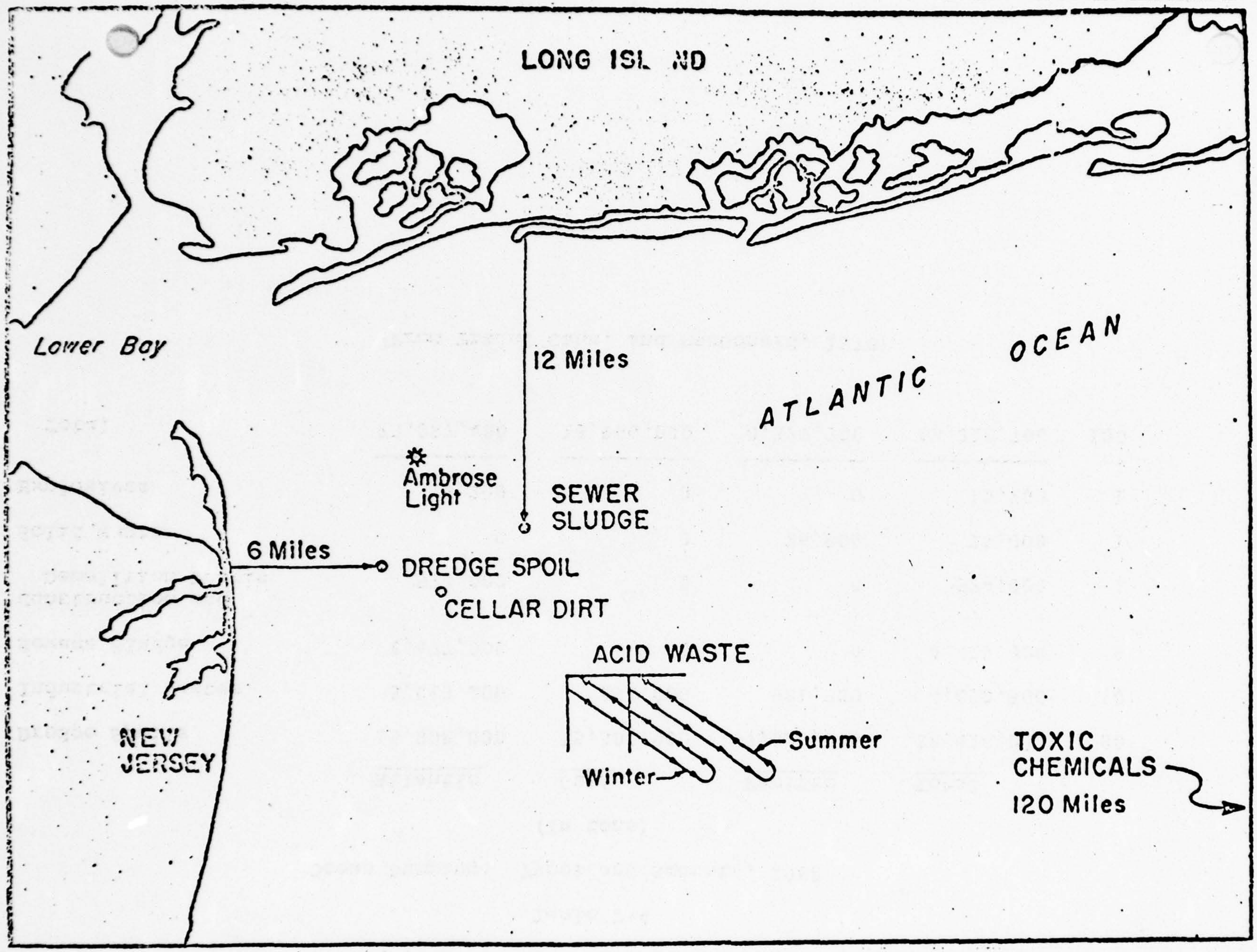
DIRECTIONS

1. PLACE STRAIGHT-EDGE THROUGH APPROPRIATE VALUES OF (A) AND (B), LOCATE INTERSECTION ON (C)
2. SIMILARLY OBTAIN INTERSECTION WITH INDEX I USING (D) AND (E)
3. OBTAIN (G) USING (F) AND INDEX I
4. PLACE STRAIGHT-EDGE THROUGH (C) AND (G) AND READ ANNUAL COST ON (H)

CHART FOR DETERMINATION OF ANNUAL COST OF ONE FOOT OF OUTFALL PIPE

BASED ON STRAIGHT LINE DEPRECIATION-AVERAGE ANNUAL INTEREST

Figure 2-2



The location of various waste disposal sites in the New York Bight
(Ketchum, 1970)

Table 2-4

Ocean Dumping: Types and Amounts, 1968

(In tons)

	Atlantic	Gulf	Pacific	Total	
Dredge Spoils	15,808,000	15,300,000	7,320,000	38,428,000	80
Industrial Wastes	3,013,200	696,000	981,300	4,690,500	10
Sewage Sludge	4,477,000	0	0	4,477,000	9
Construction and Demolition Debris	574,000	0	0	574,000	1
Solid Waste	0	0	26,000	26,000	1
Explosives	15,200	0	0	15,200	1
Total	23,887,400	15,966,000	8,327,300	48,210,700	100

(From Train, Cahn, and MacDonald, 1970)

since strong economic pressure on operators could lead to this. Hazards to public health from dumping will probably be mostly related to non-degradable toxic substances in the waste which enter the bottom of the food chain. Some concentrations of heavy metals in sewage sludge are listed Table 2-5 from Train, et al, 1970.

Dumping by barge has been more expensive historically for coastal cities than has ocean dilution by pipeline; however, as concern over the impact of Man's activities on the environment continues, the present cost gap between the two methods is expected to close somewhat. This will be particularly true for East Coast regions where distances to deep water are greater than they are in California. Burd, 1968, estimates the following costs of sludge disposal:

pipeline	$5 per ton
barge	$5 to $25 per ton

(depending on travel distance to a safe dumping area).

3.0 Impact of toxic materials and pathogens on the food chain

3.1 Toxic materials in the food chain

The effects of sanitary wastes on the marine food chain are the result of dispersal of the solid and liquid portions over large areas of water. These wastes often contain potentially toxic materials, such as heavy metals, herbicide and pesticide residues, petrochemicals and other poisonous substances. These materials are found in sanitary wastes because municipal treatment plants process a variety of industrial wastes in addition

Table 2-5

Heavy Metals Concentrations in Sewage Sludge
(in parts per million)

Metal	Concentrations in Sewage Sludge			Natural Concentrations in Sea Water	Concentrations Toxic to Marine Life
	Min.	Avg.	Max.		
Copper	315	643	1,980	.003	.1
Zinc	1,350	2,459	3,700	.01	10.0
Manganese	30	262	790	.002	---

to the residential load. Table 3-1 indicates the components of typical sewage.

Pollutants usually enter the food chain at the lower trophic levels and are biologically concentrated as they move up. Organisms feeding on lower members of the chain further concentrate and pass on the pollutants to higher organisms. The concentration of a toxic material gnerally reaches its maximum in the highest organisms of the food chain such as marine mammals, birds, and man. The example of the food chain presented in Ocean Dumping: A National Policy, is an excellent illustration of this process.

1000 pounds of phytoplankton produces:
100 pounds of zooplankton or shellfish
50 pounds of anchovies and other small fish
10 pounds of the smaller carnivores
1 pound of the carnivores harvested by man.

The biological concentration of metals can be astounding. As reported in Marine Chemistry, cadmium is enriched from 100,000 to 2.3 million times in shellfish. Other toxic metals, such as lead, chromium, copper and zinc, are concentrated from 3,000 to 300,000 times in the same shellfish. The enrichment factors in phytoplankton for the same metals are in the range of 30,000.

Pesticides and other organic residues can be concentrated in the same fashion as the metals. The often described case of the demise of the peregrine falcon as a result of DDT accumulation is an example.

Table 3-1

Typical Sewage

	mg/l
Total solids	200 to 600
Suspended solids	200 to 300
Volatile solids	200 to 350
Fixed solids	100 to 300
BOD	100 to 400

1 to 10 ft^3 of grit per 10^6 gallons
1 to 25 ft^3 of screenings per 10^6 gallons
1 to 5 ft^3 of floatable scum per 10^6 gallons
2,000-5,000 gallons primary sludge per 10^6 gallons which contain about 1,000 pounds dry solids.

Per capita sewage flows are on the order of one hundred gallons per day; but, with a heavy influx of storm water or industrial wastewater, the *per capita* flow can be (typically) three to five times higher.

3.2 Pathogens in the food chain

Indicator organisms have been given much attention in consideration of the public health aspects of sanitary waste disposal. Decay rates for pathogenic bacteria, the ratio of nonpathogenic bacteria to pathogenic bacteria, and the influence of temperature, salinity, sunlight, and microconstituents must be considered in sea water. Survival studies have been conducted of the viability of various pathogens and indicator organisms in various types of fresh water and sewage. Human euteric pathogens survive outside their hosts for periods that insure their survival in terms of reinfection of new hosts. Less work has been done on the viability of bacteria in the marine environment. Research carried out prior to 1956 is summarized by Pearson, 1956, and reproduced here as Figure 3-1.

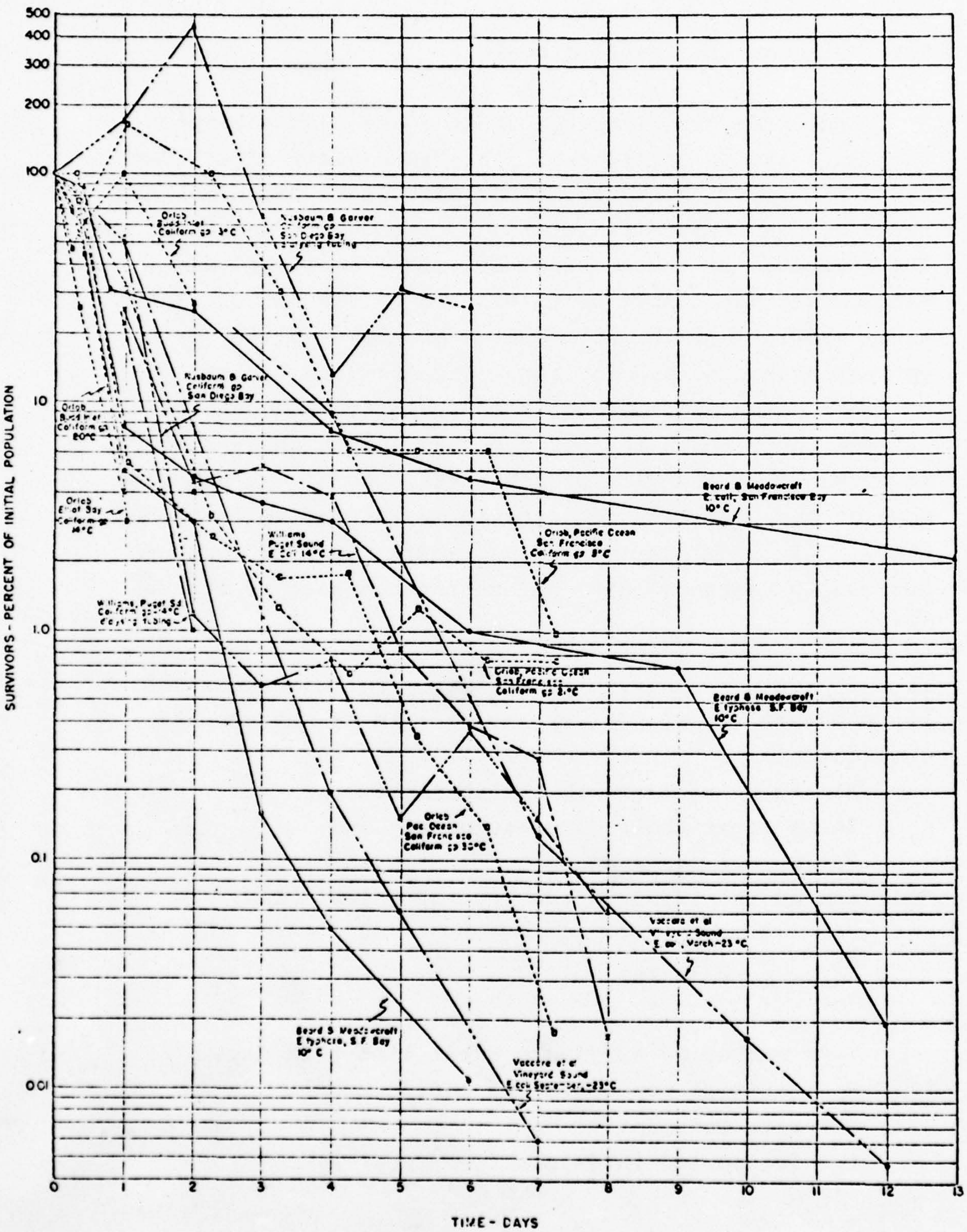
The die-away of bacteria in sea water follows the usual three phases experienced by bacteria in an unfavorable environment:

1) An initial growth or lag phase,
2) A logarithmic decrease phase, and
3) A resistance phase.

This can be expressed in the form of Chick's law:

$$\frac{N_t}{N_o} = 10^{-k\,(t-t_o)}$$

N_t = number of survivors after time t in days
N_o = initial population at t=0.
k = rate constant
t_o= lag period in days.



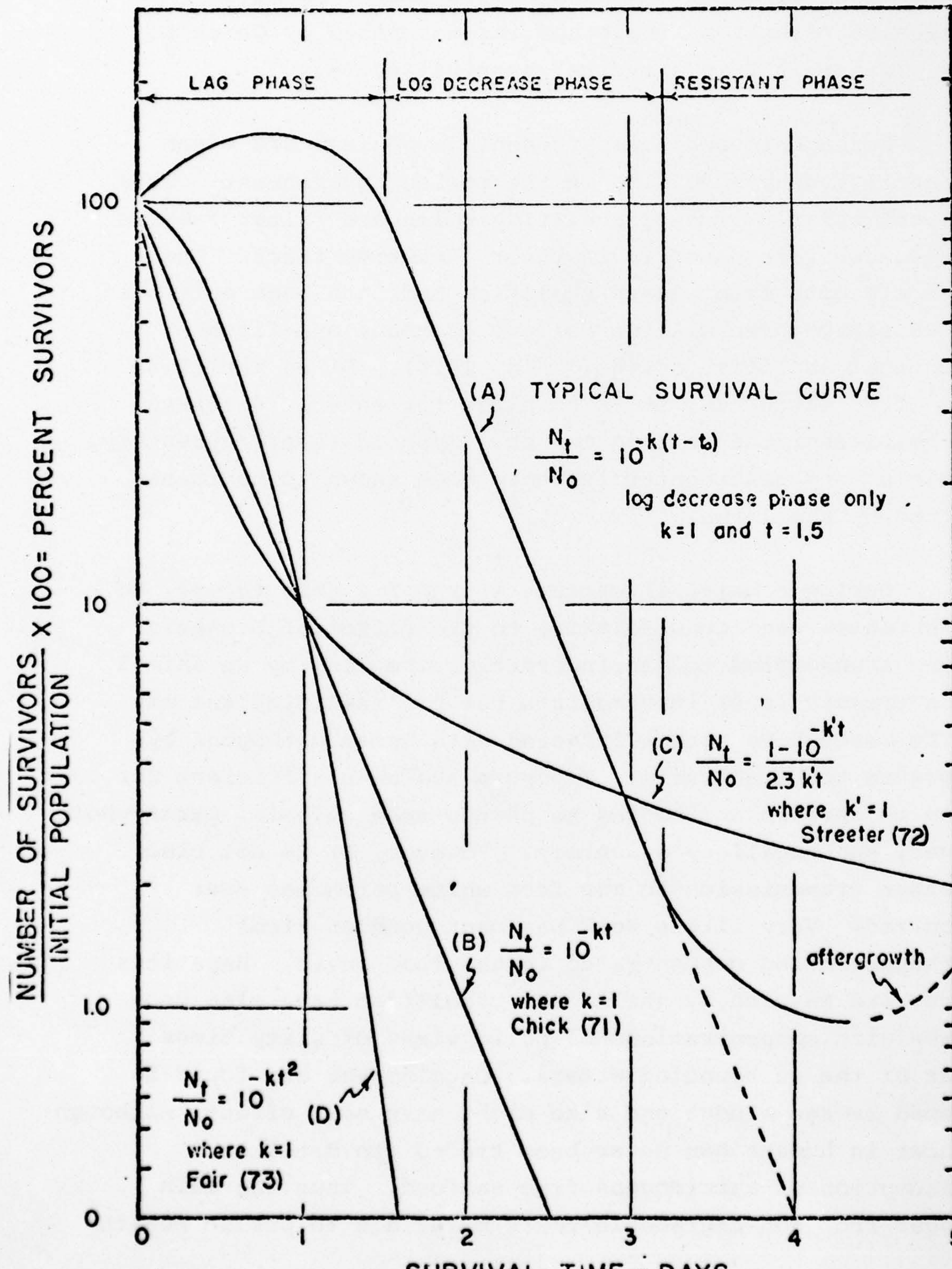
SURVIVAL OF BACTERIA IN RAW SEA WATER
SUMMARY OF REPORTED INVESTIGATIONS

More elaborate schemes have been proposed for total populations of mixed cultures, where each term of a series represents a single species described by Chick's Law. Figure 3-2 is a typical survival curve.

Pathogenic and non-pathogenic organisms are often concentrated by shellfish in the marine environment. This is particularly true of shellfish which are filter feeders and concentrate bacteria in their digestive tract. The economic loss from closed shellfish beds has been estimated to be sixty-three million dollars or about one-fifth of the total shellfish catch (Train, 1970). Since shellfish are often eaten raw, it is possible for enteric diseases to be transmitted in this manner. Typhoid fever, dysentery, cholera, and gastroenteritus have been shown to be transmitted by shellfish.

During a brief literature search for this report, no information was found relating to the effect of bacteria being transmitted to man indirectly, that is, by an animal at a trophic level intermediate between shellfish and man. White perch have become infected with human pathogens by exposure to human waste. Exposure has been sufficient for them to develop antibodies to pseudo-tuberculosis, paratyphoid fever, and bacillary dysentery. However, it is not clear whether transmission to man from white perch has ever occurred. Very little work has been done on viral pathogens being concentrated in the food chain. Hepatitus virus are carried by shellfish. Shellfish have also been taken with concentrations of polio virus of sixty times that of the surrounding waters. Carcinogens are found in dumped sewage sludge and also might have some effect, although cancer in humans has never been traced (to date) to consumption of carcinogens from seafood. Thus the main danger from non-degradable toxic materials to public health

Figure 3-2



TYPICAL BACTERIAL SURVIVAL CURVES

is from the highest trophic level and from the filter feeders. In the case of pathogenic organisms, the danger is from direct water contact and from eating species, primarily shellfish, which concentrate bacteria in their digestive tract.

3.3 The effect of the degree of treatment

The degree of treatment of sewage wastes will determine the amount and type of material that will be detrimental to the marine environment after dumping, or depositing on the bottom through a pipe discharge.

Primary Treatment

Primary treatment, table 3-2, of sewage largely removes settleable matter and does not remove dissolved and floating matter such as oils. The waste from this process could contain metals, poisonous organics such as pesticide residues, and polychlorinated biphenyls (PCB's) and would have the most deleterious effect, except for raw sewage, on the marine environment.

Secondary Treatment

Up to ninety percent of organic material is removed by secondary treatment, table 3-3, leaving untouched the refractory organics including pesticides, PCB's, and some petrochemicals. It does not remove dissolved inorganic salts, and so any danger from metal remains.

Tertiary Treatment

1. Coagulation-sedimentation removes certain dissolved species such as phosphate, and virtually all settleable solids. Organics and many of the metals would not be effectively removed.

Table 3-2

Primary Treatment

Removes: 50 to 70% of suspended solids
30 to 50% of nutrients
25 to 40% of BOD
A negligible fraction of bacteria (even 99.9% removal will leave a residual count of 10^8 to 10^9/100 ml)

Primary effluent thus has typically:

Suspended solids	- 40 to 50 mg/l
BOD	- 100 to 200 mg/l
Bacteria	- 10^8 to 10^{10}/100 ml

For typical sewage COD is roughly equal to BOD and almost always higher.

Disinfection of a primary effluent with chlorine can reduce bacteria to the 10^3/100 ml range but a high residuum of chlorine is inevitable. The chlorine demand of primary effluent is in the hundreds of milligrams per liter range.

Table 3-3

Secondary Treatment

Removes:	75 to 95% of BOD
	75 to 95% of suspended solids
	10 to 50% of nutrients

Secondary effluent has thus:

10 to 50 mg/l suspended solids
10 to 50 mg/l BOD
10^6 to 10^8 bacteria/100 ml
Nutrients in the five to twenty mg/l range

Disinfection with chlorine can reduce bacteria numbers to a range of 10^3/100 ml or less, and the chlorine demand is typically five to ten mg/l.

Activated sludge (and final clarifier) produce typically 5,000 to 15,000 gallons of sludge per 10^6 gallons of sewage (500 to 1,500 pounds of dry sludge).

2. Adsorption would remove up to ninety-eight percent of the organic material and can be effective in removing the refractory organics and other undegradable organic residues. The dissolved inorganic species containing metal salts would pass through.

3. Electrodialysis provides water of high purity; however, the remaining brine may have high concentrations of metals. If dumped, this brine could release a significant amount of potentially toxic metal salts.

4. Ion exchange backwash can be recycled through parallel units or fed to a reverse osmosis treatment unit to eliminate the need for dumping.

5. Reverse osmosis also produces water of high quality but concentrates the residue in a brine which may have to be dumped. As previously noted under electrodialysis, the metal salts are concentrated in the waste water from this process.

6. Incineration of sludge leaves an ash that is sterile and contains metallic salts. Salts of certain metals such as those of lead and mercury can be volatilized at incineration temperatures, releasing the metal to the atmosphere and thus contributing to the atmospheric burden. In addition recent evidence seems to indicate that much of the mercury in the sea arrives by way of the atmosphere. The remaining ash, if dumped at sea, is light and frothy and may not be diluted as efficiently as dissolved material would be.

4.0 Impact on the marine environment of wastewaters, effluents, and sludges

4.1 Introduction

Most Northeastern coastal cities have combined sewer systems--storm and sanitary--and it is not likely that separate systems will be built to replace them. This means a higher volume of flow during storms than can be treated by the plants. Urban run-off has been shown to be as "strong" a waste as sewage for at least part of the storm run-off periods.

There is a definite trend for maximum accommodation of industry in municipal wastewater treatment plants--so-called joint treatment (Masselli, et al). Pre-treatment of industrial wastewaters is required at least to the extent that the efficiency of the treatment plant is not compromised, but obviously the effluent from joint treatment is different from that of sewage alone. The sludges produced and required to be disposed of will contain the ingredients of the industrial wastewater in any case.

Wastewater treatment processes have two aspects: First, the digestion or destruction of some substances, converting them to simpler, more stable, more inert substances like carbon dioxide; second, the separation of conservative substances like heavy metals and insoluble matter from the aqueous phase. The separated substances end up as sludges or brines, and the aqueous phase, which ideally contains only inert salts, constitutes the effluent from the treatment plant.

As a result of new emphasis on air pollution, many gases and aerosols that used to be dispersed in air will end up in fairly high concentration in waste waters.

4.2 The character of waste as it relates to the biota

Primary and secondary sewage treatment remove characteristically more than ninety percent of the organic matter contained in raw sewage. Nutrients and other inorganic ionic substances are removed only to the extent of less than fifty percent. The ten percent of organic matter remaining after secondary treatment is not the same as the material removed or digested. The residuum consists of an assemblage of biologically refractory compounds. "Hard" detergents and "hard" pesticides are the best known examples of refractory organic substances passing largely un-degraded through conventional biological sewage treatment. Through "biological magnification" these materials can become concentrated in animals high in the food chain even though they exist in the general environment at very low levels (Benoit, 1971). The removal of refractory organic substances is a primary objective in tertiary waste treatment; the tertiary processes effective for nutrient removal are not particularly useful for removing residual organics. Two important methods for that purpose are alkaline hydrolysis-adsorption (Zuckerman and Molof, 1970), and ozonation (Holluta, 1963).

Even in the Northeast where rainfall is abundant the development of water supplies for some cities is lagging population growth and water demand. That fact was dramatically demonstrated in the drought of the mid-sixties. Water re-use will become more commonplace as wastewater treatment is upgraded. Tertiary treatment by existing techniques can produce an effluent water of suitable quality for almost any conceivable use. When and if broadly useful effluent waters are produced from wastewater treatment, there will be little incentive to discharge the waters out to sea. Recycling water necessarily involves the addition of some waste substances in each cycle of use and the removal or

separation of the added material in each cycle of treatment. The types of brine or sludge produced and their amenability to safe-and-sane disposal on land depend upon the type of waste treated and the type of treatment used.

The type of effluent and sludge or brine produced by various treatment schemes depends upon the nature of the raw waste and upon the adequacy of the design capacity and the propriety of the plant operation. For planning purposes, however, it is acceptable to consider an average or typical plant operating on an average or typical waste. For some time in the future a typical sewage should be assumed to have some industrial wastes containing heavy metals and refractory organics. In Tables 3-1, 3-2, and 3-3 were set down some typical characteristics of sewage and sewage treatment fractions. From the data of the tables and from demographic projections, the magnitude of the wastewater/sludge/brine problem in coastal areas can be estimated.

Various physical-chemical methods of treating wastewater have been designated generically advanced waste treatment methods or tertiary treatment methods. Most of these methods have been routine steps or unit processes in industrial wastewater treatment for many years. The more widely used processes are:

Microstraining
Centrifugation
Foam Flotation
Membrane Separation Processes
  a. reverse osmosis
  b. electrodialysis
Distillation
Ion Exchange
Activated Charcoal Adsorption
Solvent Extraction

Hydrolysis
Neutralization
Redox Change
Chemical Oxidation
Ozonation
Coagulation
  a. inorganic coagulants
  b. organic polyelectrolytes

These unit processes are used in various combinations and with simple physical processes such as sedimentation and heating to effect the removal or separation of substances from a wastewater.

Industrial wastes are generically much more variable than sewage. One can generalize to some extent for a single industry, but different processes within a single industry and differences in plant size within a single industry make it impossible to generalize realistically--the series of Federal reports, Industrial Waste Profiles, notwithstanding (Supt. of Documents, 1969). For industrial wastes, the only realistic approach is case-by-case (not necessarily plant-by-plant, but at least outfall-by-outfall). For Connecticut the total volume of industrial wastewaters is about equal to the volume of domestic wastewater collected in sewers; unfortunately, one cannot safely assume an average strength or typical strength for industrial waste as one can for sewage.

Sludge is treated and disposed of in a number of ways including thickening or conditioning, dewatering, aerobic or more commonly anaerobic digestion, wet-air oxidation (the Zimmerman or Porteous process), drying, incineration, or land disposal. In a typical sewage plant there are three types of sludge produced in addition to scum and grit:

a. primary sludge
b. activated sludge and sediment from final clarifier
c. digested sludge

The first two are fed to digestors for digestion, but in some large plants digestor capacity may be inadequate, and some primary and activated sludge must be otherwise handled. Plants with incinerators usually do not have digestors. Digested sludge is often stated to be odorless and stable, similar to humus, but actually it is usually quite odorous and in suspension, has a substantial BOD. Sludge incinerator ash (if combustion is complete) is similar chemically and physically to pulverized ashes from coal.

Activated charcoal adsorption is coming into more and more common use for tertiary treatment. Regeneration of the charcoal by steam yields a condensate containing all the adsorbed substances. Such a fluid is obviously not suitable for discharge to a watercourse. It is the present practice to trade in spent charcoal for new active material rather than to regenerate the beds in place.

4.3 Impact of waste on the marine environment

The community structure in plankton and benthic animals as well as resident and migrant fish populations should be well understood in order to predict the effects of waste disposal in a given area. Sensitive species will be adversely affected, and other species dependent upon them will likewise suffer. The presence of waste may favor certain species in competition with more desirable species. Assuming an environment is not grossly unsuitable to sustain a species, the important ecological factors are predation, food supply, and suitable substrate for breeding as well as for growth and

survival. The way a species will be affected can depend upon its mode of feeding--filter feeding on suspended matter, on bottom ooze, browsing and scavenging, predacious carnivory with varying degrees of selectivity or specificity. Autecological studies (natural history or habit studies in older work) probably will not have been done on all the member species of a community. Many species will not fare well in laboratory aquaria and thus will not be suitable for use in bioassay work. The actual effect of a wastewater can also be measured directly by means of in situ bioassay tests using native species of fish and invertebrates in cages or racks. If the wastewater can be simulated, the waste's toxicity can be bioassayed in the laboratory.

The bulk of Connecticut's Long Island Sound is closed to shellfishing because of sewage pollution (FWQCA, 1970, and Schwamm, 1971, conference paper). Even with upgraded sewage treatment by coastal cities and towns, it is doubtful that public health authorities would permit shellfish gathering in many places because of the existence of an outfall nearby. The common attitude among health officials on the subject of shellfish sanitation is embodied in the following quotation: "Surveys of shellfish growing areas must take into consideration the most unfavorable hydrographic and pollution conditions that may exist in the areas surveyed," (Schwamm, 1971). That is a perfectly reasonable attitude from the health standpoint, of course; however, it means in fact that there will be no shellfish gathering in estuaries or coastal embayments where there are cities or towns and hence sewage treatment plant outfalls. That fact argues for carrying outfalls out beyond estuarine waters and it focuses attention on the need for intensive study of the hydrodynamics of ocean outfalls.

One of the most dramatic and most serious effects of ocean pollution is the so-called red-tide (Bongersma-Sanders).

Red-tides are due to the inordinately prolific growth of planktonic microalgae called dinoflagellates. The growth of microalgae requires nutrients, and growth to the extent of a red-tide requires an abundant supply of nutrients from pollution. Of course, there are also biological factors and hydrodynamic factors involved in red-tides. For example, there must be an interruption or failure in the food chain which prevents grazing of zooplankton sufficient to keep the dinoflagellate population in check. In addition, the water mass containing the bloom of microalgae must be stable over some period of time sufficient to prevent the dispersal of the plankton. Some red-tide algae are toxic, which obviously can affect food-chain dynamics and also can cause massive fish kills. The decomposition of the algae blooms in embayments can result in dissolved oxygen depletion with mortality of fish and other animals.

Tertiary sewage treatment for nutrient removal is now being practiced at plants where the effluent can cause algae blooms in lakes, but the majority of coastal cities in the Northeast are only now upgrading treatment to the secondary level. Tertiary treatment roughly doubles the cost of treatment, thus one can expect a tendency to substitute an ocean outfall for upgrading treatment. Such a practice will protect estuaries from eutrophication, but it may also bring about red-tide blooms offshore to the detriment of fisheries. The increased productivity of ocean waters in regions of up-welling are well known. Up-welling mixes bottom waters rich in nutrients with surface waters poor in nutrients but otherwise suitable for phytoplankton growth. Artificial up-welling has been proposed to improve productivity in some locales. Properly located, ocean outfalls could improve biological productivity if the effluent were non-toxic and contained a balance of nutrients.

5.0 Summary and Recommendations

5.1 Because of the great value of inshore waters and estuaries for recreation and fisheries, there is very strong incentive to spare such areas from pollution by carrying wastewaters out to sea for disposal.

5.2 The incentive exists regardless of the degree of treatment now given to the wastewaters and regardless of the degree of treatment contemplated for the future.

5.3 Critical shortages in water supply (not necessarily in water itself) will provide incentives for water re-use. Recycling water requires a very high degree of treatment which will produce sludges and brines at each cycle of use and treatment.

5.4 The ashes from incinerated wastes high in toxic heavy metals might have to be stablized in cements, sinters, fire clays, or glasses before they can be safely disposed of at sea. Containerizing is another approach for very strong or hazardous materials.

5.5 Bioassay studies on a reasonably large scale and over periods of time equal to the lifetime of common marine species will be important to demonstrate the safety of marine disposal of brines and sludges. Toxic and persistent substances like heavy metals and chlorinated pesticides should be demonstrably absent or in low concentrations in the brines and sludges.

5.6 Self-purification (Benoit, 1971) consists of a combination of physical, chemical, and biological processes in which a waste is dispersed, diluted, neutralized, or broken down, and assimilated into the environment. It is virtually impossible to generalize meaningfully on the assimilatory

capacity of coastal waters for wastewaters, but the present state of knowledge of physical oceanography, water chemistry, and marine ecology will permit reasonable accurate predictions of environmental impact on a case-by-case basis.

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IMPACT OF PROPOSED ALTERNATIVE WASTE WATER MANAGEMENT SYSTEMS
MERRIMACK BASIN AND BOSTON, MASSACHUSETTS--C. A. Carlozzi

I. FUNDAMENTAL ECOLOGICAL PARAMETERS

A. Energy Flow

There are three principal sources of energy reaching any area of the earth. The first is short-wave radiation from the sun. The second is the geologic forces essentially including the potential energy of gravity and the forces of vulcanism, surface uplift and subsidence. These, in combination with the presence of water with high latent heat, produce a general and localized atmospheric condition averaged over a long period to climate.

B. Nutrient Cycle

The basic nutrients we are concerned with are nitrogen, phosphorous, potassium, calcium and iron, as well as the gases oxygen and carbon dioxide.

C. The Hydrologic Cycle

Under existing technology we are still mostly concerned with the expression of the hydrologic cycle as it appears on and beneath the land.

II. BIOCLIMATIC RESPONSES

The biota making up any particular region exist at the interface of the three energy inputs. The biota exist, therefore, in response to the proportions of solar input to geologic energy input to atmospheric energy input in any one place. The major long-term phenomenon which

which produce the biota of any region is the genetic evolutionary capacity of life to create new species and thus create new living forms and functions.

In the shorter run the process of speciation becomes less important and the process of biotic succession becomes more important. This process is one by which any area of land or water is successively invaded and dominated by a series of plants and animals generally tending towards increasing diversity and complexity in order to arrive at something approaching a steady-state condition between total production and total respiration during any annual cycle. In addition, the generally mature climax stage of succession produces production/respiration (P/R) ratios approaching 1 with very little amplitude of change in P/R behavior through time.

The concept of the closed system is one which is very important to the maintenance of ecological performance on a continuing and efficient basis. This is accomplished by the system building the mechanisms to retain essential materials (nutrients) in place, cycling them slowly and evenly from primary producers to consumers and then to the microflora and fauna which return the nutrients to the air and soil for uptake into new growth.

The relatively closed nutrient and gas cycles are accomplished through the increasing feedback mechanisms arranged among and within the structural layers of natural communities. These layers are described as Life Forms. At the highest level the dominant vegetation is generally structurally dominant. There is a progression down through lesser layers to the level of the soil and the microbiotic organisms

of the soil. In a sense one can see each structural layer of a nautral community as a broad habitat supporting its own respective population of consumer organisms at several trophic levels.

III. SUBSTRATE AND MEDIA

For all living things there is a necessity to have a basic substrate for anchorage and supplies of nutrients, and all living things are surrounded by a growth medium. For terrestrial organisms, soil is the essential substrate and air is the medium. In the case of many aquatic organisms, water is both the substrate and the medium, though for rooted aquatic plants and sessile aquatic animals the channel or basin bottom may act as the substrate. Within the substrate and the medium there is a general need for continuity of chemical quality and quantity through any annual cycle of natural growth and reproduction. This continuity does not mean a constant amount or proportional arrangement of chemical substances within the substrate or medium each day of the year, but rather a constant pattern of chemical conditions which is more or less repreated year after year, season after season.

There is also a need to maintain continuity of physical conditions on the same basis as chemical quality and quantity. It is the pattern of temperature changes and other energy inputs into an environment on an annual basis that constitutes the physical parameters within which speciation has occurred, successsion has taken place, and the adaptive amplitude of any individual species making up the community is determined.

IV. CONCEPT OF ECOSYSTEM STRESS

Because the surface of the earth, the atmosphere, and the amount of short-wave radiation reaching the surface of the earth are never

constant through long periods of time, it can safely be said that all living systems exist under a state of environmental stress.

A. Long-Run Stress

1. Geologic Changes.

These changes tend to be related to the basic geological processes of vulcanism, tectonics, and long-run peneplanation.

2. Climate Changes

Climate changes are related to patterns of occurance of climatic phenomena which produce conditions of hot, dry, cold or wet environmental conditions. These patterns express themselves seasonally or on a diurnal schedule but in the long-run retain a considerable constancy. This is due to the fact that short-wave radiation inputs acting on the surface of the earth with subsequent entropic breakdown to long-wave radiation create sufficient energy on land and atmospheric water to produce the basic seasonal and diurnal distribution of hot, dry, cold, wet conditions for any one place.

B. Short-run Stress

1. Geologic Changes

The short-run phenomena tend to be localized in geography or instantaneous in time. These can be local earth movements such as earthquakes, land flows and erosional patterns. Their effect is usually brief and tends not to alter the basic distribution or structural arrangement of the biota, except on the site effected.

2. Weather Extremes

Aberrations in the behavior of weather may produce local stress. Low probability precipitation patterns, early frosts or late springs, droughts, hurricanes and tidal waves are examples of short-run stress of this category. Once again, such stresses tend to be localized and may be significant for the area affected, but they usually do not change the overall pattern of speciation or structural arrangement of biotic communities within a bioclimatic region.

V. ECOSYSTEM RESPONSE TO STRESS

Essentially the ecosystem behaves like a "cybernetic system"--that is, it has three fundamental capacities: it is self-creative. It is self-repairing. And, it is self-adjusting. Basically the self-creative function is related to genetic evolution and the capacity to develop new living forms and functional diversities through long periods of time in response to the more profound, long-run stress factors. The self-repairing capacity is generally expressed as the successional series of developmental communities leading to the more stable, mature ecosystem. The self-adjusting capacity is related to the adaptive amplitude of each individual species to endure under the normal patterns of annual, seasonal, or diurnal changes in physical mechanisms of the individual organisms represents the shortest run capacity to deal with stress.

VI. BASIC HUMAN ACTIVITIES CAUSING STRESS

A. The most fundamental change which human beings in their

activities exert upon the stress patterns effecting ecosystems is the change in the time distribution of events and/or substances as they occur in the environment. These changes would be exemplified by the following activities:

1. A removal of inorganic and organic stock from a place faster than growth or import systems can replace stocks.
2. An import of inorganic and organic substances and energy to a place faster than assimilation and growth systems can adjust to the imported factors.
3. Alteration of the regimen of water on the land and to a lesser extent in the atmosphere.
4. Development and introduction of substances or energy, either in kind or intensity, outside the evolutionary experience of the genetic stock making up the ecosystem in question.
5. Acceleration or retardation of natural geologic processes, especially that of peneplanation.

B. Removing Biological System's "Cybernetic" Capacity

This act would be accomplished by any of the following occurrences:

1. The extinction or the extirpation of species from an ecosystem.
2. The alteration of the structure of natural communities. This could occur, for example, by the removal or the degradation of one of the life form layers of any community, thus, reducing the spectrum of its habitats and causing a loss of its dependent animal and microbiotic flora and fauna.
3. Forcing the biota of a place to exist at any extreme of their adaptive capacity as a general life condition.

VII. POSSIBLE IMPACT OF ALTERNATIVES OF PHYSICAL-CHEMICAL WASTE WATER SYSTEMS ON THE ECOLOGY OF EAST CENTRAL AND SOUTHEASTERN NEW ENGLAND

Since all the physical-chemical systems proposed appear to have a similar effluent output quality, considerations of ecological impact will be the same for all PC alternatives.

A. There are three significant negative impact potentials:

1. The improvement of the qater quality of the Merrimack River Basin through the PC systems would make Merrimack River water available for water supply for the Boston Metropolitan Region. It would appear from the alternatives offered that this water resources advantage gained would be utilized in a water supply system. This means that there will be a withdrawl of water from the Merrimack River for such water supply. Under the proposal by the Water Disposal Group it seems evident that only a part of that water will return to the river.

   It is estimated that eventually up to 30% of the total flow of the Merrimack might find its way into the Boston Metropolitan Area water supply system. Depending upon the time of the year of withdrawl and the rate of withdrawl as a proportional of seasonal average low flow, there could be an ecologically important change in the regimen of the lower reach of the Merrimack River. It is difficult from the description of the water supply and waste water treatment systems to determine exactly what the pattern of withdrawl and return might be, though it seems possible that roughly 50% of the water entering the

system would be treated in a proposed South Boston facility and effluent discharged directly into Boston Harbor. The other half of the water would be treated in a North Boston facility with a probable discharge back into the Merrimack. Thus, at its most intensive operation the water supply system might result in an attrition of 15% of the flow capacity of the Merrimack River in its lower reach. The impact from this would be a reduction of flow and change in current, and current velocity, possibly affecting the migration of fish which orient according to current and the forces of flow. The change would also affect other more local aquatic biota which are dependent upon an existing ratio of solar energy to current flow and thermal energy. There could also be a tidal bore encroachment further up the Merrimack with a consequent habitat change in the lower reach from fresh water to estuarine conditions.

2. Effluent quality of the treated water being discharged into the Merrimack would seem to be extremely low in nutrients, especially phosphorous and nitrogen. Both elements would be expected to be present at less than 1 PPM in the effluent. There is no information at this point as to what is the natural base line of nitrogen and phosphorous inputs from the land and the atmosphere. All present readings are based upon current loads of untreated waste water and thus those leads would be masking

the natural base line inputs. Assuming there would be a significant reduction in nutrient inputs because of the super-clean effluent this would probably result in a reduction of primary production and a change in the composition of aquatic flora favoring those plant species which can tolerate low nitrogen and phosphorous levels.

3. Disposal of the sludge resulting from the physical-chemical treatment alternatives is an ecological risk if one assumes that incineration is the means of reducing the amount of sludge. Heavy metals and nitrogen oxides could produce an air pollution condition. If one assumed storage of the sludge until the heavy metal problem can be solved, then this risk is obviated.

VIII. POSSIBLE AND LAND DISPOSAL TECHNIQUES

A. Rapid Discharge System

This system seems to require a minimum of land disturbance. Approximately six square miles of land area is required for this system and quite obviously where the system is developed all existing biota would be removed and a rapid discharge basin would be substituted. This essentially would support little or no significant biota and thus there would be a net six square mile loss of biologic productivity. Depending upon the use of water treated by the rapid discharge method following treatment, it may or may not result in attrition of flow in the Merrimack River. If it did result in such attrition, then the same impacts as

described for the PC systems would be in effect.

B. Irrigation

The irrigation system has perhaps the most varied and wide-spread impacts of all the proposals be they physical-chemical or land disposal.

1. There might possibly be a nitrogen and phosphorous loading of local surface waters from the effluent except for the 120-130 day growing season in Maine, New Hampshire, and Plymouth County in Massachusetts. Any disposal of effluent on the land before or after the growing season would lose the advantage of green plant take-up of nitrogen and phosphorous as a treatment device.

2. Removal of permanent relatively steady-state ecosystems which have P/R ratios approaching 1 and substituting for them very unsteady state systems in which P/R ratios would greatly exceed 1 during the growing season and be greatly less than 1 during the non-growing period.

3. There would be a reduction or an absolute loss of forest and wetland wildlife species when crops of any kind were substituted for the existing biota.

4. Assuming little or no recycling of effluent in the public water supply systems, there would be a possible agumentation of coastal stream flows. These would change the physical character of the estuaries and also the salinity gradients within the estuaries in the Cape Cod portion of the system.

5. The large storage impoundment constitutes a geologic change with an additional high risk of sepsis. There would, of course, be a removal of existing ecological conditions for possible non-living water environment (except for anaerobic bacteria).

C. Overland Flow System

There seems to be only one possible negative impact from this system assuming that it is as widespread in its use as anticipated. (That is, a maximum of one inch of effluent added per week to any area receiving the overland flow.) This impact is related to a possible BOD loading over tight soil pockets in the forest areas. This might result in developing anoxic conditions in the surface soils with a consequent destruction of vegetation. The seriousness of this effect is dependent upon the proportion of tight soil depressions to the total surface area being used. Were this to be a small proportion, say 5 to 10% of the total area, and well distributed throughout the area, then the loss of vegetation would be minimally important. However, should the percentage of tight soil depressions and pockets amount to more than 10% or be concentrated in several larger areas within the disposal land, then the loss of vegetation might result in the opening of a canopy and a change in microclimatic effects. There could be a change in the insolation to the forest floor and a subsequent change in the species composition and structure of the understory layers and life forms of the forest. (There is a very slim and outside possibility that the discharge of effluent may affect the ground nesting of birds and the subsoil biota such as earthworms, small mammals and the microflora

and fauna. This seems not too likely because of the relatively small amount of effluent treatment by the overland flow means.)

IX. POSITIVE IMPACTS AND RESOURCE GAINS FROM THE PROPOSED PHYSICAL-CHEMICAL AND LAND DISPOSAL SYSTEMS

In all cases one would have to recognize a considerable gain in water wuality should the Merrimack River Basin be freed of its pollution load by the institution of either physical-chemical or land disposal systems. The reduction of toxic substances and BOD and COD loadings from domestic and industrial pollution would in all likelihood result in a more diversified aquatic environment with a higher rate of primary productivity and consequently a diversification and lengthening of the entire food chain. Adding trophic levels would improve the efficiency in the feedback mechanisms to stabilize aquatic ecosystems and would undoubtedly result in a higher utility of the river for the production of fish and all other aquatic life.

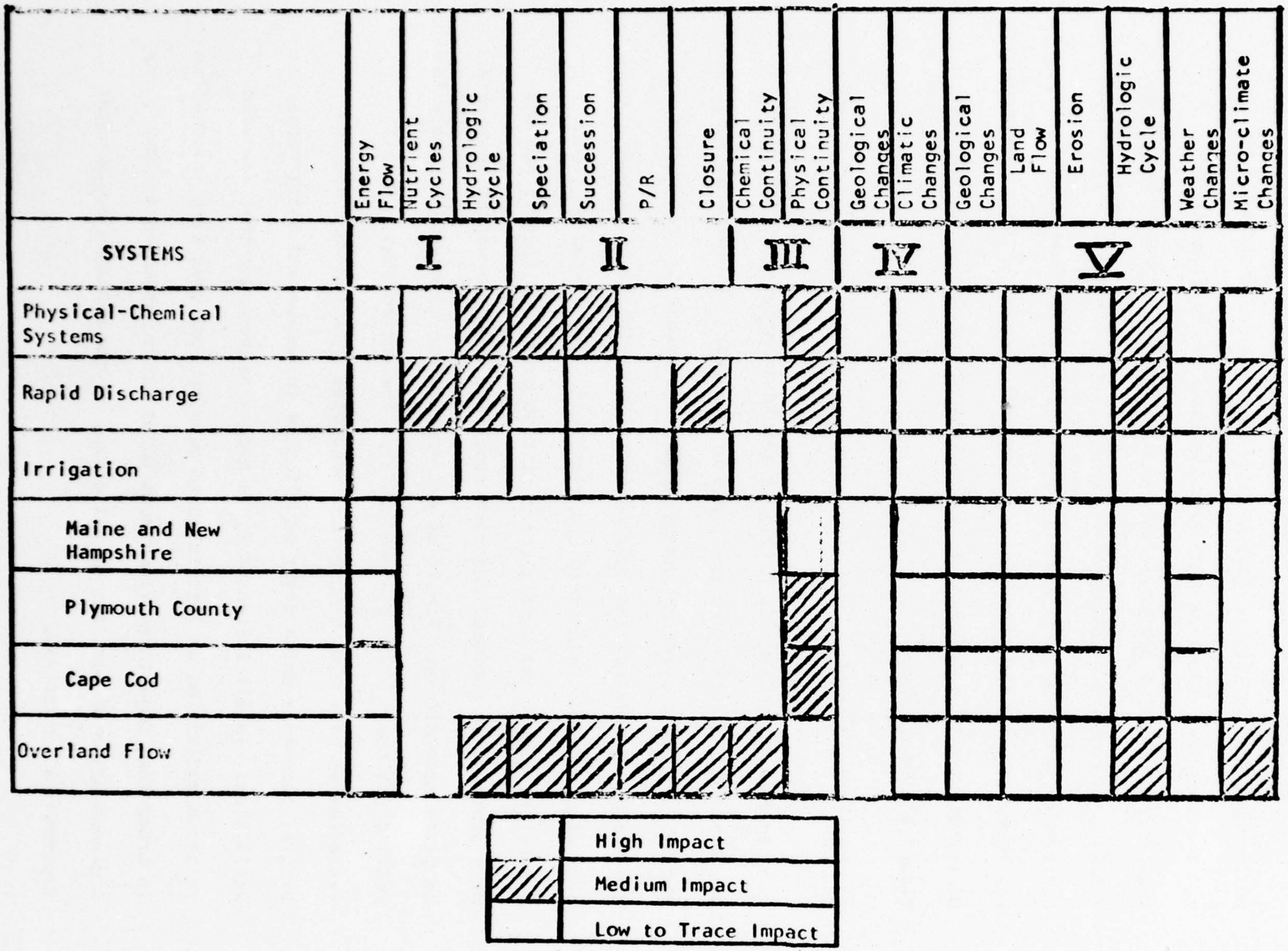
The irrigation system offers a unique opportunity to increase farm wildlife habitat if the management for such habitat is made a part of the total system. Such increase in farm wildlife would be a very real asset to the recreation opportunities in the Eastern Massachusetts area in which farm game are the most populat species sought after by hunters. It is exceedingly important to note that with the proposal for shifting to farm products such as high-valued crops in vegetables that there would be no quarantee that farm game would be a natural condition of such an agricultural regimen. There would have to be a specific recognition of wildlife production as a planned secondary benefit of the cropping system in order to guarantee that wildlife would be present.

The overland flow system seems to offer considerable opportunity to increase the quality of forest site conditions. This would be accomplished by increasing nutrient availability to forest trees, thus raising primary productivity and efficiency of energy conversion. Assuming no harvest of commercial timber as a result of this, one would achieve a richer and more productive community of consumers including all forms of wild animal organisms. However, one could take advantage of increased site conditions by increasing the harvest of commercial timber and wood fiber.

X. THE IMPACT MATRIX

In reading the Impact Matrix it should be noted that the variables are organized according to the parts of the text. In terms of long-run and most profound types of change or impacts resulting from any of the system considered, the lefthand portion of the chart is considerably more important than the righthand. The variables listed across the top of the Matrix chart tend to move from longest run and most profound to shortest and most localized and thus weighting should be given accordingly. A word of extreme caution is needed not only in reading the chart which follows but also the entire text. In all instances we have almost no established base line for what are the natural phenomena which might be affected in medium and short-range activities. In all instances it is highly recommended that specific research activities be instituted to develop such base line information in order that departures from those norms can be assessed following the implementation of portions or all or any of the proposed waste water treatment alternatives.

NEGATIVE IMPACT POTENTIAL OF WATER DISPOSAL AND LAND DISPOSAL SYSTEMS



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IDENTIFICATION AND ASSESSMENT OF SOCIAL IMPACTS

Merrimack Basin
Wastewater Management Study

Submitted to:

U. S. Army Corps of Engineers

July 19, 1971

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1.0 SOCIAL IMPACT IDENTIFICATION: METHODOLOGY

1.1 Definition of the Problem

Once there was a river. Undistinguished, because beauty then was no exception, it was called by the Indians merely "swift water place," or Merrimack. In the days before white men came in great numbers to what is now Northeastern Massachusetts, the river was generous in its abundance. The hunters who knew its pools and the secret places of its forest could take as they needed: finfish, alewife, menhaden, salmon; shellfish, clams and blue mussels; fur-bearers and venison. Man and the river lived in harmony. There could be no contest between them because the river was an insuperable power its two-legged children could not, dared not challenge. To the Redman, the water was the source of life itself, hospitable when its spirit was honored and terrible in its vengeance on the profane.

But in time "new men without color," as they were called, came. There were only a few at first, and they depended on Merrimack for sustenance even as the Indian did. But as their numbers grew, so did their audacity and even before this was a nation, they felt the stirrings of a different independence--a freedom from the tyranny of Nature. With the plow, the rifle, and a mandate from Genesis, men began in earnest to subdue the Earth. For the river, that meant unaccustomed demands; to serve rather than to be served. Man required in endless quantity food and drinking water. In time, Merrimack became a river highway for trade ships from every continent. All this the river could and did provide.

But its generosity was rewarded only with new burdens. As the people prospered, they demanded power for the machines in their mills. As before, they took from the river, this time not just its natural fruits, but its very energy. Dammed, channelled, and then let go to turn more wheels downstream, by mid-nineteenth century the river had become a foul sluiceway. The townspeople ceased to value its natural character. Since the mills needed only its motive force, cleanliness was incidental, and the Merrimack carried unimaginable quantities of human and industrial waste to the sea. The Industrial Revolution and its psychology of dominion permanently altered the age-old

balance between the integrity of Nature and the disruptive potential of the human species. With new tools and new aspirations, men conquered the water.

In retrospect, the cost of their victory was too high. The mills which once flourished in the lower Merrimack Basin died, leaving as legacy a river so degraded, so spent, that it could never again restore itself. Gone was the wildlife; gone too were purity and loveliness. In their place were filth and disease. Worse still was the change in the attitude of the people. Whereas their fathers had regarded the river with respect and even reverence, they saw only a worthless wastewater. Because the river had no more to give, they expected nothing and abandoned it to ever-increasing pollution loads. Soon, no one remembered what the water had meant in terms of nautral productivity or aesthetic satisfaction. The Merrimack was, and is still, an obscene ditch.

But what if it were clean? The generations who thought the water useless and then hopeless are passing away, and people concerned with the vitality of the Merrimack Basin have come to see in a healthy river tremendoes social and economic potential. As part of a growing national rejection of mindless exploitation, they are reaffirming the old values that once gave the river a unique place in the life of the region. Their expectations are rising, and they ask, "Why not clean water?" "Why not here?" "Why not now?" It is no longer enough to neutralize the Merrimack's threat to public health or to screen its offensiveness from the public eye. In a world more aware of the perils in short-term profit, citizens are seeking ways to repair their damaged natural environment and make it fully and perpetually productive. Many communities now recognize that just as a source of future water supplies, the cleanliness of their river is a matter of necessity, not just principle.

Happily, it is possible to restore the Merrimack River; the technologies, the talent and the financial resources lie under our hands. But the effort required to use those tools effectively will be enormous. To undo two centuries of harm will exact a price in dedication incalculable in dollars and cents. This paper examines the significant changes in the social and economic character of the Basin that a clean river might make. It presents considered

opinions on the varying impacts alternative pollution abatement strategies may have. To those who must design for the future, this paper offers options for survival.

1.2 Study Approach

1.2.1 Objectives

The principal task of this research is to identify significant social changes which may result from the implementation of any one of seven water pollution abatement schemes. Developed by the U.S. Army Corps of Engineers, all these strategies address the goal of maximum feasible water quality in the Merrimack River. For the purposes of this impact analysis, we have accepted as a given the premise that all seven solutions are technically feasible; that is, with additional study in Survey/Scope, any one can become operational. We do not make any assumptions about the desirability of any of the schemes. However, an even-handed assessment is crucial to the purposes of this, and the Corps', entire analysis. More specifically, the intent of this paper is to:

(1) Array for every decision-maker concerned with the continued viability of the Basin the social and economic implications of a series of pollution solutions,

(2) stimulate constructive comment from a range of actors representing diverse interests, and, ultimately,

(3) integrate their reactions and design an accommodating institutional framework through which solutions can be implemented.

The first objective is a product of hindsight. As a society, we have been too easily beguiled by new technologies. What at first appeared to be attractive innovation has, in cases like the automobile, proved to be the source of serious problems. In the Merrimack Basin especially, much of the historic pollution problem can be attributed to ill-considered, or at least incompletely considered, decisions to adopt new production techniques. No more convincing argument for a cautious approach to new "black boxes" can be found than the pollution disaster caused by the introduction of the very mechanized equipment which revolutionized the textile industry and redirected

the economic history of New England. Therefore, realizing that technologies can produce undesirable consequences, this study seeks to identify possible repercussions in advance of irrevocable desisions. Clearly, that identification cannot be exhaustive, but it can be at least suggestive of the areas in which detailed analysis carried out in Survey/Scope can be most productive.

The second and third objectives stem from a recognition that social forces are as powerful a determinant of successful pollution control as mechanical ones. Even if a perfect technology were possible, it would be useless unless it were acceptable to the majority of people it affected. Too often otherwise sound environmental management schemes have stumbled over conflicting political and institutional interests. Regionalization--though compelling as a proposition of logic--can be a Pandora's Box of tribulation. It is critically important, therefore, that planners see the full range of public opinion and make their work responsive to it. By accommodating constructive comment from every quarter, these alternative abatement schemes can be complemented with designs for a viable administrative framework to implement them.

1.2.2 Plan of Analysis

The business of impact identification and assessment is still more an art than a precise science. Despite the continuing efforts of social scientists to build rigorous analytic models, the complexity of relationships between human beings often defy quantification. Like the ecosystem of which the species itself is a part, interactions between individuals form a seamless web. To pluck any part of that web sets up vibrations felt throughout it. Thus, to determine with certainty where and in what way a given strategy will have effect is a task for the soothsayer. What is possible, however, is some educated forecasting based on available data and sound intuitive thinking. To structure that thinking, we have used a three-dimensional matrix composed of the following elements:

(1) Impact categories, delineating aspects of human activity,

(2) sub-regions, geographic areas of the Basin large enough to make gross change detectable, and

(3) purification schemes, and their attendant processes.

By considering each solution with respect to every relevant impact category and localizing effects wherever possible, we can distinguish at least the broad contours of aggregate change.

Further, to avoid semantic confusion, this analysis uses the following terms and definitions uniformly:

(1) impact	a perceived or predictable change in the behavior or attitudes of a community; a shift characterized by measures of direction, intensity and duration
(2) community	a body of people have common organization, interests or purposes
(3) effect	a judgmental evaluation of the nature of an impact which may vary by opinion group
(4) alternative	one of three generic approaches to wastewater recycling: water, land, or a combination of the two
(5) scheme	one of seven strategies using processes related to recycling alternatives: three all-water, one all-land, and three combinations
(6) EMA	Environmental Management Area; geographic entity composed of one or more Basin sub-regions; EMA boundaries are established by the service area for any one scheme.

To establish benchmarks against which impacts can be measured, Section 2.0 presents profiles of each of six sub-regions within the Basin: Lowell-Lawrence-Haverhill, Fitchburg-Leominster, and the New Hampshire Counties of Rockingham, Hillsborough, Merrimack, and Carroll. Section 3.0 introduces the impact categories and discusses the shape of the Basin future without the introduction of innovative technical and administrative approaches. Then, Section 4.0 examines each of the seven solutions offered by the Army Corps of Engineers in terms of those same classifications. Finally, Section 5.0 looks across schemes to identify the most important social impacts. Wherever possible, an attempt will be made to assess the effects of those summed changes on the New England region or the nation as a whole.

1.3 Caveats

- This document regards "wastewater" as a misleading and inappropriate term for what is, in reality, an inestimably valuable resource. Used water, like any substance, must be husbanded intelligently in a world grown too poor for squander.

- The authors make note of the time and data constraints under which this document was prepared and caution readers that its contents are not intended as prophesy. If they have succeeded at least in stimulating the thoughts of others and indicating what questiona are properly addressed in Survey/Scope, their purpose is well served.

2.0 IMPACT MATRIX ELEMENTS

2.1 Sub-Regional Profiles

2.1.1 FITCHBURG-LEOMINSTER REGION

Scene:

The North Nashua is a color-coordinated river. Just below a large chemical complex, it matches the surplus green paint of a billboard frame. Here in "Marlboro Country," orange brown curls of dried slurry cake the shore and have the tint of filter-tips. On a steamy July afternoon, the river's presence is everywhere. The firemen assigned to Water Street Station keep the windows shut.

A. Location and Characteristics

- North-central Massachusetts, bordered on the north by Ashburton, Ashby, and the State of New Hampshire; on the east by Pepperell, Groton, Ayer and Harvard; on the south by Lancaster and Sterling; on the west by Princeton, Hubbardston and Gardner.
- 167.02 square miles
- Part of the Nashua River Drainage Basin; hilly terrain to 1,000 ft. above sea level
- Nashua River and Squannacook River

B. Population

- Growth: 1955-65, population increased by 9,063, or 11%. In the same period, there was an excess of births over deaths of 12,413, and an estimated net out-migration of 3,350.
- Race and Ethnicity: In 1960, 1.5% of the population was non-white; 91.4% of foreign stock and 12.0 foreign-born. Nearly half of the foreign stock were Canadian, and the remainder were Italian, Irish, Finnish, and British.

B. Population (continued)

- Age: Median age in 1960 was 30. Area has a higher percentage of its population between 14 and 65 than does the state as a whole.

C. Economic Base:

- 1,761 firms with annual payroll (1967) of $167,398,938, and employment of 29,775, almost entirely in core cities of Fitchburg and Leominster.

- Manufacturing: employed 18,276 persons (1967); seven largest manufacturing groups, in order of persons employed, were rubber & plastic products, fabricated metal products, paper and allied products, machinery (except electrical), apparel and other finished goods, textile products and chemicals.

- Trade: 70 wholesale firms employed 787 employees and 608 retail firms employed 5,422 persons. 1958 Census of Business reported total retail sales for area of $95,249,000, of which 67.6% spent in Fitchburg and 29.2% in Leominster.

D. Municipal Finance:

- Assessed Valuation: for the six towns comprising the SMSA, the total assessed valuation in 1962 was $277,424,000.

- Tax Rate: From $36.00-115.50/$1000 assessed value, depending on assessment rate. Average about $40.00/$1000 of actual value.

- Tax Levy: Total 1968, $16,268,000.

- Debt: Total net debt, January, 1969, $22,767,000. 90% in Fitchburg and Leominster.

E. Housing

- Type: 47.8% single-family units, 20.5% 2-family units, remainder 3 or more. 55.3% owner-occupied; 2.6% vacant.

- Age: 76% built prior to 1940. 80.5% judged by 1960 Census to be in sound condition.

E. <u>Housing</u> (continued)

- Value: Mediam value in 1960 was $11,700.
- Monthly Rentals: 1960 median, including utilities and heat, was $68.00, compared to $75.00 for the state.

F. Education

- Number of school children: 17,324 in public schools plus 6,438 in private schools.
- Cost per pupil from $468 in Leominster to $597 in Fitchburg.

G. Transportation:

- Served adequately by air, bus, highway, rail and trucking facilities.
- Fitchburg Municipal Airport has 2 runways and regular flights.

H. Municipal Services

- Electricity: Provided by Fitchburg Gas & Electric Co. and Massachusetts Electric Co.
- Gas: Provided by Fitchburg Gas & Electric Co., Massachusetts Gas Co., and Boston Gas Co.
- Water: Fitchburg receives water from surface sources; Lunenburg, Shulay, Townsend and Westminster from ground sources; and Leominster from both.

2.1.2 LOWELL - LAWRENCE - HAVERHILL REGION

Scene:

These are cities with bridges. Since the tide does not go much beyond river mile 15.7, the footings of the Groveland Bridge catch "suspended solids" in their eddies; beer cans, feces, and newspapers, among others. In Lawrence, the towers of vacant mill buildings stand beside a workhorse river, out of work. Until recently a billboard erected for motorists on Route 495 declared the city "The Industrial Showplace of the Seventies!"; and a visitor remarked, "Yes, the eighteen seventies." Shad run up as far as Lowell and die at the dam.

A. Location and Land Characteristics

- Northeast Massachusetts, including a small portion of New Hampshire; consists of the Lowell SMSA which contains the city of Lowell and the towns of Billerica, Chelmsford, Dracut, Tewksbury, Tyngsborough and Westford, and the Lawrence - Haverhill SMSA containing those two cities and the towns of Andover, Georgetown, Groveland, Merrimac, Methuen, North Andover and West Newbury in Massachusetts and Newton, Plaistow, and Salem in New Hampshire.
- 314.56 square miles
- This region lies along the Merrimack and Ipswich River Basins. It is part of the Seaboard Lowland Region which is characterized by meandering streams and considerable marsh areas along their valleys.

B. Population

- Growth: The Eastern part of the region consisting of the Lawrence - Haverhill SMSA increased in population by only 1.8% in the decade between 1950 and 1960. It grew at a rate of 6.2% between 1955 and 1965, according to state census figures. The slow rate of growth is the result of substantial out-migration. The western part of the region, focussed on Lowell, grew at a rate of 17.1% between 1950 and 1960, and by 20.2% between 1955 and 1965. In the Lowell SMSA, the excess of births over deaths was higher and the out-migration was lower than in Lawrence - Haverhill. The total population of the two areas was approximately 373,000 in 1965.

- Age: Median age in 1960 was just under 31 years. The area has a larger percentage of its population between 14 and 65 than does the rest of Massachusetts.

- Race and ethnicity: .5% of the area's population is non-white. In the Lawrence - Haverhill SMSA, 62% of the population is foreign born, or of foreign stock. This is true of 46% of the population in the Lowell SMSA. Most of the foreign countries represented are Canada, Italy, Ireland, United Kingdom, Greece and Poland.

- Income: The median income for the region was slightly over $6,000 in 1960. The region has approximately 4% fewer families with incomes over $10,000.

C. Economic Base

- Region once dependent on textiles and somewhat later, shoes. Areas are now more balanced, economically, although the textile industry is still a major employer.

- 6,290 firms in the area employed 103,678 persons, with a total payroll of $570,734,543.

- Manufacturing: Most of the area's residents engaged in manufacturing; major industries are textiles, electrical machinery, leather and leather products; printing and publishing, plastic and rubber products, apparel and other finished goods, paper and allied products.

- Trade: 2,382 wholesale and retail firms employ 12,598 people. Census of Business reported total retail sales for area of $471,284,000.

D. Municipal Finance

- Assessed Valuation: In 1968, for the entire region, $808,772,000.

- Tax Rate: Varies from $32.00 to $197.00/$1000 assessed valuation, depending on assessment rate. Average about $40.00/$1000 of actual value.

- Tax Levy: Total, 1968, $70,483,000.

- Debt: Total net debt, January, 1969: $87,755,000.

E. Housing

- Type: 53% single family units, 18% two family units, remainder 3 or more. 50.7% owner occupied; 3.0% vacant.

- Age: 78% built prior to 1940. 84% judged by 1969 census to be in sound condition.

- Value: Median value in 1960 approximately $12,700.

- Monthly Rentals: 1960, approximately $66, including utilities and heat, compared to $75 for the state.

F. Education

- Number of school children: 107,209 in public school plus 22,843 in private schools.

- Cost per pupil ranged from $412 per pupil in Merrimac to $631 in Andover.

G. Transportation

- Three commercial air facilities within the Region: Lawrence Municipal Airport in North Andover, Haverhill Airport and the Haverhill - Riverside Airport.

- Served adequately by air, bus, highway, rail and trucking facilities.

H. Municipal Services

- Electricity: Massachusetts Electric Company supplies power for the entire area, except Groveland.

- Gas: Supplied by the Lowell Gas Company, Haverhill Gas Company, and the Lawrence Gas Company.

- Water: Georgetown, Merrimac, West Newbury, Chelmsford, Dracut, Tewksbury and Westford depend on ground water sources; Billerica filters water from the Concord River and Lowell filters water from the Merrimack River. Other municipalities have surface sources, and Andover has both.

2.1.3 NASHUA - MANCHESTER SUB-REGION
HILLSBOROUGH COUNTY, NEW HAMPSHIRE[1]

Scene:

Nashua is the southernmost city to dispose of its sewage in the Merrimack. Manchester, to the north, graces the river with untreated waste from a population equivalent of 72,500 per day. The fortress-like walls of the Amoskeag take no note, however; the city draws its water from Massabesic Lake.

A. Location and Characteristics

- Hillsborough county is in southeastern New Hampshire. Nashua and Manchester lie on the North-South line of the Merrimack River, 20 miles from the sea.
- The county is large: 890 square miles.
- The river is about 100 feet above sea level; the highest point in the county is 2,300 feet.

B. Population

- The Hillsborough region is termed a "lesser metropolitan place" with a total population of 225,000 persons at a density of 270 persons per square mile. Manchester and Nashua are New Hampshires' most populous towns at 88,000 and 56,000 in 1970. They hold 65% of the total county population.
- Growth: The county grew relatively slowly from 1940 to 1960, but is now growing more rapidly as emigres from urban locales to the south and rural areas move in. The current annual growth rate is about 2.5% higher than the national average. Manchester has begun to lose population, but Nashua is growing rapidly.

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1 Only one of many inconsistencies stemming from jurisdictional perversity, New Hampshire data is organized by county rather than by SMSA as in Massachusetts. We have reported county data as collected, noting urban characteristics where possible because land disposal would take place in outlying rural areas. In lower New Hampshire, the mesh of Corps study areas with county boundaries is fairly good. In the Winnipesaukee subregion, we are less fortunate; the boundary separating Belknap and Carroll Counties cleaves the lake neatly in two. Data for Belknap was not available.

- Race: In 1966 0.4% of the county was non-white. This proportion is slowing increasing.

- Age: The people of Hillsborough County are somewhat younger than the general U.S. population; in 1966, the median age was 29.1 years.

C. Economic Base

- Textiles were the principle industry in the Manchester area until the Amoskeag Mills closed in 1936. The area's industrial activity has since diversified into leather, electrical products, apparel and food.

- The pattern for Nashua is similar, except Nashua is absorbing a little of the excess high technology from Route 128 ringing Boston.

- There are about 1,000 farms in Hillsborough County. These are small, but prosperous relative to national agricultural indices.

- Manufacturing: The three largest sources of industrial employment (5.2% of all jobs) in 1964 were;

  1. Leather: 8,700 employees,
  2. Electrical Equipment: 6,300 employees,
  3. Textile Mills: 4,300 employees.

- Employment: In 1964, the employment picture was bright; unemployment stood at 4% and the average wage was higher than in 77% of the U.S. counties.

- Commerce: Trade and services accounted for 32% of all jobs in 1964 and are slowly increasing.

D. Municipal Finance (Manchester)

- Assessed valuation (n.a.)

- Tax Rate (n.a.)

- Public Revenue (1964-1965). Expenditures ($13.1M) exceeded revenues of $11M.

- Debt: Outstanding department, $8.7M.

E. Municipal Finance (Nashua 1964-1965)

- Public Revenue: Expenditures ($7.4M) exceeded revenues of 6.0M.

- Debt: Outstanding debt, $7.8M.

F. Total County Finances (Hillsborough, 1962)

- Public Revenue: Expenditures ($31M) exceeded revenues of $28M.

- Debt: Long-term debt is rapidly rising. In 1962 it stood at $30M.

G. Housing (Manchester, 1960)

- Type: 40% single-family dwellings. 49.3% owner occupied.

- Age: 86% built before 1950. 80% judged to be sound.

- Value: Median value $11,900 in 1960.

- Monthly rentals: Median rent $61/month.

- Density: 3.2 persons per dwelling.

H. Housing (Nashua, 1960)

- Type: 51.5% single-family dwellings.

- Age: n.a., 82% judged to be sound.

- Value: Medium value, $12.900.

- Monthly Rentals: Median rent is $66/month.

- Density: 3.2 persons per unit.

Education

- In 1970, Manchester had 24,000 pupils from kindergarden through Grade 12. Enrollment is expected to grow at about 1.6% annually.

- About 5,000 students attend six post-high school institutions in Hillsborough County.

J. Transportation

Highways

- Both Nashua and Manchester are on Route 3, the Everet Turnpike. Manchester is also linked to Lawrence and Boston by Interstate 93. Three interstate bus lines serve the county.

Air

- Manchester is adequately served by a commercial airport and Nashua is close to a small private field. There are four Manchester-New York, and two Manchester-Boston flights daily.

Railroads

- The Boston & Maine Railroad serves both Nashua and Manchester. Freight service is adequate, but passenger rail transportation is severely limited.

Local

- Local transportation in Manchester is provided by a city transit system with nearly complete coverage of the metropolitan area on a thirty-minute basis during week days.

K. Municipal Services

- Water and Sewage- Manchester
  Only Manchester within its SMSA has an adequate piped water supply to serve its whole area. The Manchester water works estimates that Lake Massabesic could serve a population of 150,000 persons. Additional water is likely to be needed in the period of 1975-1980. Most of the Manchester SMSA is served by a piped sewerage, through which collection lines are antiquated, and inadequate for modern flows.

- Water and Sewage - Nashua
  The Pennichuck Water Company serves 95% of the developed land in Nashua from ground water sources and a facility on the Pennichuck Brook. Nashua has one sewage treatment plant emptying into the Merrimack, but only about 40% of the city is served by the municipal sewage system.

- **Police and Fire Department - Manchester SMSA**
  Manchester maintains over 200 firemen at an annual cost of $1.2M (1964). The Manchester area is protected by over 120 policemen.

- Police and Fire Department - Nashua
  No information.

- Health and Hospital Facilities: The Manchester region is served by four hospitals, exclusive of the VA Hospital, with a 1967 capacity of 640 beds. Hillsborough County had 120 physicians in 1962. This is significantly lower than the national average of 142.

2.1.4 ROCKINGHAM COUNTY, NEW HAMPSHIRE

Scene:

Rockingham County bears the mark of the great glaciers which ground down from the north. It is hard and stony country, full of lakes. Some are still isolated from the works of man, and retain the cold, sparkling purity of their youth

A. Location and Characteristics

- Rockingham County is in the southeast corner of New Hampshire, bounded by Massachusetts and the sea. The western border is in Hillsborough County - a few miles short of the Merrimack River.
- 691 square miles.
- The County is drained both by the Merrimack and the Piscataqua River - which flows into Portsmouth Bay.

B. Population

- Rockingham is classified as a "suburban" county with a population density of 202 persons per square mile. Nearly a third of the residents are employed outside the county.
- Growth: Although Portsmouth (the largest city with a 1970 population of 26,000) is losing people, Rockingham County grew from a population of 100,000 in 1960 to a population of 140,000 today. This is attributable to steady immigration.
- Race: In 1966, 1.9% of the County was non-white - up from 1.6% in 1966.
- Age: In 1966 the median age was 27.0.

C. Economic Base

- In 1964, 36% of the persons employed in the County worked in manufacturing; most of the remainder were employed in trade and other related services.
- Total payrolls are growing at about 80% annually, just matching the population growth and inflation. Total payrolls in Rockingham County reached $18M in 1964.

- In 1964 the three largest employment sources were:

  1. Leather Products: 3,580 employees.
  2. Resturants and Taverns: 984 employees.
  3. Retail Food Trade: 953 employees.

- In 1966 per capita retail sales equalled $1,493.

D. Municipal Finances

- Although local, public revenue ($16M) exceeded expenditures by nearly 9% in 1962, the long-term debt rose slightly to $16M.

- Rockingham County depends upon property taxes for 76% of its revenue.

E. Housing (Rockingham County, 1960)

- Type: 82.5% single-family dwellings; 70.4% owner-occupied.

- Age: 72.5% built before 1950; 73.3% judged by 1960 census to be sound.

- Value: Median value in 1960 was $11,700.

- Monthly Rentals: $77 per month.

- Density: In 1960, 3.0 persons per dwelling unit.

F. Education (1960)

- Achievement: 49.7% completed high school.

- School Enrollment: 22,236 persons.

- Funding: In 1962 the local districts spent $8.1M on education. This represents 55% of total government expenditures, and amounts to $79 per capita.

G. Transportation

Highways

- Interstates 93 and 95 provide North-South access to Maine, Lawrence and Boston. State Highway 101 (currently in a state of repair) goes east from Manchester to the sea.

Ports

- Portsmouth handles ocean-going freighters.
- Railroads: n.a.
- Air: Portsmouth is serviced by commercial airlines.

H. Municipal Services (Portsmouth)

- Water and Sewage: In 1964 Portsmouth spend $1.2M on water and sewage.
- Fire Protection: In 1964 the fire department budget was $213,000.
- Police Protection: 1969 police department budget was $306,000.

2.1.5 CONCORD SUB-REGION

MERRIMACK COUNTY, NEW HAMPSHIRE

Scene:

The approaches to Concord along the river are lovely. Terraced fields on the banks show the marks of careful tending. Other features of the flood plain are not so pleasant. A shopping center sprawls across the east bank opposite the state Capitol building. Out-of-town visitors say, "What a shame!" and wonder why the river is empty.

A. Location and Characteristics

- Merrimack County is in southeast New Hampshire, just north of Manchester. It is bounded on the east by Rockingham County and the Winnipesaukee River area. To the west it is bounded by the foothills of the mountains in Sullivan County.
- The county is large at 929 square miles.
- The Merrimack River flows 40 miles through the county. passing through Franklin and Concord, its two most populous cities.

B. Population

- Growth: The population is growing at about 20% annually, reaching 81,000 in 1970. Of this, 46% live in Franklin (7,300) or the state capitol at Concord (30,000).
- Race: Merrimack County is nearly 100% white.
- Age: In 1966, the median age was 31.1 years.

C. Economic Base

- In 1964, 45% of persons employed worked in manufacturing. Most of the remainder worked in trade and services.
- Manufacturing: Three sources of employment accounted for 24.3% of the total payroll ($18M in 1969):

  1. Electrical Machinery: 1,411 employees
  2. Printing and Publishing: 1,316 employees
  3. Textile Mills: 1,074 employees.

- o Trade: In 1966, per capita retail sales equalled $1,338.

D. Municipal Finances (Merrimack County, 1962)

- o Assessed Valuation: (n.a.)
- o Tax Rate: (n.a.)
- o Public Revenue: Local public revenues ($11.9M) exceeded expenditures ($11M).
- o Debt: General debt outstanding, $12.5M.

E. Housing (Merrimack County, 1960)

- Type: 77% single family dwellings; 68.8% owner occupied.
- Age: 86% built before 1950; 72% judged by 1960 census to be sound.
- Value: Median value was $9,600.
- Rents: Median rent was $67 per month.
- Density: 3.0 persons per dwelling

F. Education

- o Achievement: In 1960, 45.3% of adult population had graduated from secondary school.
- o School Enrollment: In 1960, 15,183 persons.
- o Funding: In 1962, $5.4M was spent on education in Merrimack County. This is 49% of government expenditures and $79 per capita.

G. Transportation

- Highway: Merrimack County is adequately serviced by highways (principally Interstates 89 and 93), trucks, and buses.
- Rail: Concord is the rail hub of central New Hampshire (B&M Railroad).

- **Air:** The Concord Municipal Airport currently has one 3,500-foot and two 4,000-foot runways.

H. Municipal Services

- Water and Sewage (Concord): The city-owned water works draw from ground-water wells and Penacook Lake. Due to extreme drought conditions in 1964, an emergency 18 inch supply line was built from Turkey Pond to Penacook Lake. The present water supply is inadequate and new sources are being investigated. The volume of water available for fire fighting is hampered by mineral deposits in the old iron mains.

  About 80% of Concord's population is serviced by the municipal sewerage system. The wastewater system built since 1935 is separate from the storm water system. Concord is presently constructing two new treatment plants intended to raise the water quality in the Merrimack and Penacook Rivers to bathing standards (Class B-1). These plants will provide an ultimate capacity for a population of 40,000.

- Fire Protection: In 1964-1965, Concord allocated $405,000 to fire protection.

- Police Protection: The 1964-1965 budget for the Concord Police Department was $39,900.

2.1.6 WINNIPESAUKEE RIVER AREA

A. Location and Characteristics

- This region consists of six towns in two counties lying along the Winnipesaukee River between Webster Lake and Lake Winnipesaukee.

B. Population

- Merrimack County:

Northfield	2,157
Franklin	7,106

- Belknap County:

Tilton	2,575
Sanborn	966
Belmont	2,435
Laconia	14,508

o Total: 29,747

Because the region does not coincide with any political subdivisions, data are not readily available in the categories used for the previous regions.

2.2 A Structure for Impact Assessment

The table on the following pages identifies 15 social impact categories which are considered significant for evaluating the effects of the seven schemes using processes related to the recycling alternatives. In each category, impacts can be felt along a number of different dimensions. Hence, different impact measures have been suggested, each corresponding to one of these dimensions.* The impacts must also be measured in different units, depending on the nature of the impact. These suggested measures encompass units of amount, size and time. Finally, impacts are likely to be felt over different time periods. For the purposes of this stage of the analysis, we have defined only two time periods: short and long. Short term impacts are defined as those which are likely to occur before the processing scheme is actually in operation, or within about five years of the present time. Longer term effects are those which will not be felt until the quality of the river water begins to change. In the Survey/Scope phase of the analysis, it may prove worthwhile to distinguish between medium and long term impacts.

Given some indication of the size of the impacts, as well as their direction, it will be possible in the Survey/Scope phase to develop graphic profiles of anticipated impacts on each sub-region, given the alternative recycling schemes proposed. Furthermore, given an indication of how activities in the impact categories are valued by residents of the sub-regions or the their representatives, it will be possible to evaluate quantitatively the overall impact of the alternative schemes proposed.

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*Clarkson H. Oglesby, Bruce Bishop and Gene Willike, "A Method for Decisions Among Freeway Location Alternatives Based on User and Community Consequences," Highway Research Record #305, Socioeconomic Considerations in Transportation Planning, Highway Research Board, National Research Council, National Academy of Sciences--National Academy of Engineering, Washington, D.C., 1970, pp. 1-14.

Table 1. Social Impact Measurement

Impact Category	Suggested Measures	Units	Time Period
1. Land Use	Net change in the percent distribution of acres devoted to industrial, commercial, residential, recreational and other land uses.	Percent	Long
	Number of feet of incompatible land uses separated by the facility, minus the number of feet of compatible uses separated	Feet	Short & Long
	Net change in the amount of land available for development	Acres	Long
2. Population	Net changes in the age, income, race and ethnicity distributions of the local population	Percent	Long
3. Municipal Finance	Loss of assessed valuation as a percent of community total	Percent	Long
	Increase in assessed valuation resulting from improved water quality	Dollars	Long
	Net change (gain/loss) in tax revenue resulting from improved water quality	Dollars	Short & Long
4. Commercial Activity	Net change over normal trends in gross wholesale and retail sales	Dollars	Short & Long
	Net number of businesses located (displaced) by central facility	Number	Short & Long
5. Housing	Net change (increase/decrease) in number of housing units by number of bedrooms by price, (OR)	Number	Short
	As a percent of community's total stock	Percent	Short
6. Education	Net change in amount of classroom and other educational space required for projected change in school-age population resulting from in- and out-migration.	Sq. Feet	Short & Long
	Net change in cost of teacher and other education staff required for projected change in school-age population resulting from in- and out-migration	Dollars	Short & Long

Table 1. Social Impact Measurement (continued)

Impact Category	Suggested Measures	Units	Time Period
Education (continued)	Net change in cost of providing school services because of changes in busing	Dollars	Short
	Use of treatment plant facilities for educational programs	Days/Year	Short
7. Leisure Opportunities	Net change in the total number of acres of parks and playgrounds in the Environmental Management Area	Acres	Short & Long
	Net change in the extent to which planned recreation space meets American Society of Planning Officials planning standards relating types of space to population characteristics	Percent	Short
8. Cultural Opportunities	Total number of churches, historical sites or other cultural institutions taken	Number	Short
	Cost of relocating churches, historical sires and other cultural institutions, minus compensating payments	Dollars	Short
	Increase in locational amenities (eg., improved site planning, additional parking, etc.,) as a result of relocation	Number of Improve-ments	Short
9. Transportation	Net change in travel time from major residential areas to activity centers: health, commercial, recreation, employment, education, cultural	Minutes/Trip x Trips/Day	Short
10. Municipal Services	Net change in cost of providing water, sewerage, and garbage service	Dollars	Short & Long
	Net change in cost of providing police and fire protection	Dollars	Short & Long
	Net change in residential heating costs	Dollars	Short
	Net change in residential insurance rates	Percent	Long

Table 1. Social Impact Measurement (continued)

Impact Category	Suggested Measures	Units	Time Peri
11. Security	Change in the number of reported crimes against the person or against property within sight of the control facility	Number	Short & Lo
	Number of positive and negative statements about the opportunities for system failure, as revealed by a content analysis of local news media	Number	Short & Lo
12. Community Image	Changes in property values along river	Dollars	Short & Lo
	Changes in property values adjacent to treatment facility	Dollars	Short & Lo
	Number of positive and negative statements about the community as revealed by a content analysis of local news media	Number	Short & Lo
13. Community Cohesiveness	Total number of community groups taking a position (making a public statement) for or against the treatment facility	Number	Short
14. Citizen Involvement	Total number of community groups involved in the planning of the project, times the level of their involvement, according to the following scale of increasing involvement: 1. attendance at hearing; 2. citizen opportunity to critique plans at public meetings; 3. periodic workshop planning sessions with community representatives; 4. community advocate planner participates on equal basis with technical staff in all planning activities; 5. appointment of arbitrative hearing officer who makes final decision in case of dispute between community and Army engineers	Weighted Number	Short
15. Institutional Relationships	Total number of jurisdictions involved in the totality of the construction process for a treatment facility	Number	Short & Lo
	Number of enforcement actions brought against non-compliant offenders; municipal, industrial	Number	Short & Lo

3.0 THE BASELINE SCENARIO

Recognizing that the purity of the nation's waters has been seriously degraded, the Federal government, acting in concert with the several states, has moved to bring about pollution abatement. In a series of legislative actions, Congress has authorized the Environmental Protection Agency to give state and local jurisdictions every assistance in their efforts to construct water pollution control works. Accordingly, the Commonwealth of Massachusetts and the State of New Hampshire have designated water quality standards for their waterways and drafted implementation schedules for the building of municipal and industrial wastewater treatment plants. Implementation schedules establish for each offending discharger a step-by step construction sequence (site selection, submission of preliminary engineering reports, etc.) which culminates in actual plant start-up.

No one would be so naive as to think that the costly and complex administrative process implicit in that strategy is without flaw. In fact, significant numbers of taxpayers have expressed concern at how little change in overall water quality their substantial dollar investment in treatment facilities has brought. Recalcitrant cities, towns and industries can and do delay action on their pollution control committments. Delays in implementation waste precious financial resources and generally reduce the effectiveness of a water pollution control program. However, the Massachusetts Division of Water Pollution Control and the Water Supply and Control Commission in New Hampshire have made substantial progress toward the restoration of water quality, a task regarded by many as impossible.

Taken together, their plans for the cleanup of the Merrimack call for the construction of a total of nine secondary treatment facilities by 1975. Their distribution is as follows:

Lowell-Lawrence-Haverhill	3
Nashua	2
Concord	2

If the building of these activated sludge plants and the related industrial works can proceed without major schedule disruptions, it is reasonable to assume that water quality in the main stream of the Merrimack will meet established civilian standards before the end of 1976. Concurrently, the social and economic

life of the Basin will change, partially as a function of development over time and partially because cleaner water will provide new opportunities. For example, portions of the river previously inaccessible because of unhealthy pollution levels may be opened for recreational use.

The analysis below suggests what the nature of some of those changes might be and provides a baseline scenario with which the involvement of the Army Corps and the implementation of innovative technological or administrative techniques can be compared. For convenience, the presentation is ordered according to the impact categories set out in Section 2.2.

3.1 Land Use

There is no major change forseeable. In what are already urban areas, the building of activated sludge plants is not seen as a stimulus for the redistribution of acreage devoted to industrial, commercial, residential, or recreational uses. If the example of other locales is any measure, the building of water treatment facilities will alter land use patterns no more than any other large public works project. Although the improvement in water quality brought about by the plant once in operation might well increase the total water area suitable for public recreational uses, the facility itself is not likely to become an important architectural focal point or the leading edge of any reconsideration of a community's land allocation scheme. Generally, plants will be located adjacent to the water in areas devoted to industrial or at least commercial use. If the conventions of construction are observed, the public cannot expect to gain access to the river shore; the buildings themselves will be located as near to the water as possible to reduce piping costs, and the onmipresent chain-link fence to discourage vandalism will keep visitors off plant grounds, however attractively landscaped. The amount of land available for new development in the urban core will not be significantly affected, unless the facility itself is proposed for a prime site. More likely, the capacity of the plant design will in part determine a community's attitudes to land uses in the suburban fringe or ex-urban areas of rural character. For example, if the vigorous growth of residential tracts and the increase in waste volumes they generate were consistent with the capability of treatment works to handle that effluent, a community would be inclined to encourage new development and the concomitant broadening of its tax base. However, if

plant design could adequately treat only present flow plus anticipated storm runoffs and existing collection systems feeding the facility were in need of replacement of costly extension, the emphasis on growth might fall to increases in density within the downtown area where developmental control is more easily achieved. Given proper operation, plants may bring about an increase in the desirability of waterfront locations for business or residential purposes, but this effect would become noticeable only over a long term of five to ten years. These trends apply with equal force to the Lowell-Lawrence-Haverhill, Fitchburg-Leominster, Nashua, and Concord sub-regions. More detailed plant location data would permit site-specific evaluations. No firm data were available for treatment works in Manchester, New Hampshire.

In a rural or semi-rural environment such as the Winnepesaukee area, one must assume that the usual patterns of urban agglomeration will take shape, and that waste treatment will be contemplated only when the correctional methods of sub-surface or water disposal become inadequate. When the need for water treatment grows to large proportions, construction of municipal works will proceed as they have in the lower Basin and the same psychologies of expanded development will apply.

3.2 Population

In terms of the indigenous population, patterns of out-migration already established in the lower Basin are likely to continue uninterrupted. Positing the continuance of the general economic decline in the textile and shoe industries, one can expect that the children of the generation now experiencing dislocation will seek employment elsewhere. The direction of their movement will be either outside the Basin entirely -- to metropolitan Boston -- or northward toward the Manchester Standard Metropolitan Statistical Area which experienced a modest 10.2% increase in population over the decade from 1950 to 1960, to Salem in Rockingham County which grew by some 118% in the decade between 1960-1970, or toward the western part of the lower Basin and the Lowell area

The short-term effects of the construction phase will be felt most directly in the immediate vicinity of the several plants planned. A

discernable influx of construction workers can be expected, although the size of individual treatment facilities is the ultimate determinate of labor needs. If plants are small, it would be unrealistic to assume that the transient worker population would increase significantly, or find employment of sufficient term to justify permanent residency.

In the long-run, the existence of a cleaner river may attract families from outside the Basin, manifested first as an increase in the number of recreation visits to the lower river reaches most proximate to Boston. The steady rise in the desire of the urban dweller to experience the uncrowded calm of the outdoors may be translated into actual resettlement beyond even the present Boston surburban fringes. Should such a phenomenon take place, first emigres are likely to be professional people who will either commute to businesses or academic institutes in a metropolitan area like Boston, Manchester, Lowell, or Portsmouth or engage in activities which can be practiced outside the urban context of labor and capital concentrations.

In the mid to upper Basin, clean water and job opportunities connected with construction may draw down population levels in adjacent Maine and even Canada. Since the unskilled labor supply is large and a dwindling agriculture will not be affected under the existing abatement plans, it is likely to gravitate toward the loci of building activity.

3.3 Commercial Activity

In this area, trends will closely follow the population curve. Should an in-migration of temporary workers occur, one could expect an increase in local, but not necessarily downtown, commercial activity. The disaggregation of local businesses caused by the proliferation of shopping centers has made their future uncertain at best; to pin hopes for a new vitality on public works construction alone would be unduly optimistic. In the short run, however, local buying will increase modestly, if only in established centers which rely on the automobile for clientele. Unless communities can detect a tendency of workers to settle permanently in their area, to rely on the continuance of increased buying would be risky, and "shake-out" strategies would be appropriate.

Displacement of business is possible, of course. Relocation, through, is likely to be a matter of scale rather than number, the

number of industrial river-front occupants outnumbering small businesses in shore locations. It is important to point out, however, that, executed under local aegis, the siting and construction of treatment work is likely to proceed with uppermost consideration given to the integrity of the tax base. If the example of past efforts elsewhere is any guide, communities will delay and even resist compliance with anti-pollution orders just to avoid the hazards of industrial displacement.

With scant municipal resources to soften the blow of losing a local industry, their solicitude is not surprising. The expected increases in assessed valuation resulting from improved water quality would be little consolation, because they will bear fruit only over a span of five to ten years, at best. Local communities are most concerned with the immediately painful effects of unemployment, loss of tax revenues, and a poor public image. In general, though most taxpayers are kindly disposed toward sensible environmental management, they are not anxious to pay for it out of public resources tha must meet an ever-growing number of equally serious demands -- schools, fire and police protection, utilities, etc. A further discussion of "community willingness" follows under Institutional Relationships.

3.4 Housing

Housing needs are rooted in population trends. If out-migrations continue, urban housing is likely to become more easily available but poorer in quality. Should in-migration take up the slack at least a short-term increase in rental activity is foreseeable. Beyond the urban area, suburban development will continue and increase in tempo as local residents abandon moribund urban areas or new extra-Basin families leave their own homes in other cities or stagnant rural economic climates.

In either case, the bulk of any new housing construction at least for the next decade will almost certainly be in the "middle ring" communities between purely urban and purely rural landscapes. The ability of a treatment plant to handle increase loads will tend to spur the growth of existing communities close to collection lines. Further, the development of new communities in what have previously been rural or semi-rural locations is also predictable. No local decision-maker should encourage

such new growth unless he is prepared to deal with the increased demand for public services and the further reduction of open space implicit in uncontrolled suburan sprawl.

In the Winnepesaukee Region, clean water and the availability of increased water supplies are going to produce noticeably greater seasonal influxes of population. Increasing demands for cottage housing will pressure land-owners to sub-divide and sell or lease waterfront property. Without adequate zoning and waste management controls, new development may, in time, create the very atmosphere vacationers left home to avoid.

3.5 Education

Clean water in the Merrimack affects public education in several ways; attendance, costs, transportation and curriculum. In terms of attendance, increases in numbers of in-migrating families with young children exact greater demands on existing classroom space. Though increases spaced over a long term tend to be absorbed comfortably (increasing tax revenues and economic activity making new resources available), sudden rises in numbers of school-age children can strain physical plant and teaching resources. It is not likely that a community would reject such an influx merely on the grounds of educational dislocations, but small towns with few facilities or urban places with more but poorer facilities may have to endure overcrowding or establish double sessions.

The costs associated with new school construction and staffing are well-known to every taxpayer. Unless a treatment facility itself will displace an educational institution (an extremely unlikely eventuality) new building based on temporary demands requires careful evaluation. Each locality must examine its own priorities for expenditure and calculate the returns it might expect from so substantial an investment. In the lower and upper reaches of the Basin, particularly, large capital outlays may be inadvisable in the Concord-Manchester region, where population curves are likely to ascend smoothly even without water-related activities, such facilities are likely to be needed in any event. Given the strictly local nature of treatment systems under this plan, abatement works and their attendant transmission lines are not likely to disrupt district lines or access routes. Busing distances may increase as new housing developments grow, but communication itself will not be hindered for more than brief periods, if at all.

The availability of clean water may bring young people closer to their natural environment and, indirectly, teach them the values of careful husbandry, but no direct in-classroom effect can be reasonably predicted. The construction of the plant itself, for all normal intent, would excite no more interest than the groundbreaking for a new Post Office. Case study suggestion: Vernon, Vermont; site of 860 megawatt nuclear generating facility under construction by Vermont Yankee.

3.6 Leisure Opportunities

Perhaps the greatest impact produced by the existence of a cleaner Merrimack will be its new accessibility to the public at large. Beaches of the river which have previously been closed to recreational activities involving water contact will presumably be reopened. Public bathing beaches on the river, officially abandoned before World War II because of serious pollution threats to the health and safety of swimmers, can once again serve a shore-hungry populace. Urban areas like Manchester, Nashua, Fitchburg-Leominster, and the Lowell-Lawrence-Haverhill group sorely need such recreational outlets for their citizens, young and old. Though a demand for increased public waterfront also exists, it is likely to be countered by private interests. Since improved water quality will make waterfront property all the dearer in time, space otherwise available for leisure activity will be put to tax-producing commercial purposes. In fact, plants themselves may be an obstacle to physical contact with the river's edge and obscure sight lines to pleasing vistas. Possibilities of increased recreational boating exist throughout the length of the Merrimack, with the estuary being the foremost beneficiary in terms of sport fishing increases. Most probably, the public is unlikely to associate a conventional facility treating human and industrial waste with leisure-time pursuits.

The impact that compliance with existing state implementation schedules might have on the future park and playground planning appears to be negligible. However, existing facilities like the large State park being assembled in the West Newbury-Newburyport bank of the Merrimack will profit directly from a clean water "magnet" for visitors.

3.7 Cultural Opportunities

As in the case of businesses, the probability of an existing church or museum being taken to provide construction space for a treatment facility are extremely low; the costs of moving or duplication are simply too high, and communities must think in terms of total loss. Not so carefully protected, however, are structures having less tangible values. For example, since plants tend to go in riverfront locations and since those areas are likely to be the oldest, and most dilapidated sections of the urban core, local values placed on antique commercial or residential buildings will be low. In fact, given the need to locate a less-than-desirable plant somewhere, the immediate choice may fall on the very areas which best reflect the historic character of a city. This is not to argue for the preservation of otherwise "useless" structures which detract from the downtown image. But it is the unusual case when treatment plant siting design takes cultural factors into consideration.

3.8 Transportation

This is an extremely broad area, -- though no less so than the others, -- and we can suggest only a variety possible trends in transportation (1) to and from places of employment, (2) education, (3) recreation and other leisure time activity, and (4) commercial activity.

Employment, by itself, is a variable sensitive to other components in the profile of economic development. If we can rely on the prognosis presented above under Commercial Activity, transportation so it relates to worker mobility may evolve in two complementary modes. First, if the in-migration of workers becomes significant and the suburban perimeters of industrial areas like Manchester, Nashua, Fitchburg-Leominster and Lowell-Lawrence-Haverhill experience marked growth, the incidence of commuter trips into the urban core will rise sharply. If the automobile is the principal means of transport, cities can expect additional demands for parking space. Since such demands are usually met at the expense of previous space ultimately more useful to humans than cars, serious consideration ought to be given to the revitalization of surface mass transit. Longer distances and times are involved in communication to and from jobs likely to be held by professional in-migrants and outside their immediate area of residence. In these cases,

one would expect that automobiles would continue to be the carrier of choice. Certainly, if railroads or buslines could be stimulated to provide convenient and efficient inter-city transit, that would be desirable. Where that is not likely, existing roads will have to bear the additional vehicular traffic. The need for new highway construction is unlikely to arise, save in the course of natural, long-term population increases. Transportation to and from schools, as stated above, is not likely to be disrupted, though new access routes will have to be provided if school population numbers and distribution warrant.

Recreational transport is, by far, the activity class most predictably on the increase. If the pressures felt by urban residents outside the Basin and city dwellers within the Basin are as great as week-end trip statistics indicate, clean water on the Merrimack and the attendant opportunities for new water-based leisure activities will attract thousands to at least the most southerly and northerly reaches of the river. The estuary alone is within two hours driving time of most of metropolitan Boston and millions of people anxious to escape the monotony of macadam and the neighbors next door. Salisbury, Massachusetts, for example, even though its amusement park and beach facilities have limited appeal, will be the terminus of a four-lane connector from Route 495, the outer circumferential highway ringing Boston. This access road will be used heavily only during the warm-weather months, will require the relocation of several businesses, and the destruction of the last vestiges of commercial agriculture; however, the pressures for construction are overpoweringly strong. Much the same kind of development is foreseeable for other localities throughout the Basin, and local officials should be aware of its pitfalls.

Commercial transport beyond worker commutation, will increase in parallel with industrial activity. If clean water can stimulate existing manufacturing operations or attract new ones heretofore excluded because of low water quality, trucking in and out of urban Basin areas is likely to grow. Rail transport, long untended, may show signs of renaissance though the stimulus would have to be extremely large and of long duration. Plant construction would produce at least a short-term hauling demand, both in terms of site preparation and component delivery, but that activity

could be expected to drop sharply once plants become operational. Other transportation modes like the airplane may be affected, though most likely recreational flying out of municipal airports will be the first area to show signs of change. Should population increases justify the expansion of now spotty commercial air service, federal funds available for facility improvement will be sought after by all likely cities and towns. Air travel patterns may change, too, if the decentralization of Logan International Airport and the creation of mediam-distance terminals is ever implemented.

3.9 Municipal Services

In terms of utilities and public services like fire and police protection, the availability of clean water is likely to have both primary and secondary effects. Obviously, the most direct and immediate change will come in the form of greatly increased water supplies for household consumption. Not only will quantity, and the possibilities for ex-urban and suburban development increase, but water quality itself will serve as an impetus for new drinking water demands. In areas which have relied on the river as a source of water supply despite its grossly polluted state, clean water requiring minimal treatment will represent a cost-savings, though the net benefit will depend on the extent to which present purification works become burdensome. For communities which have been forced to look to land sources both surface and ground-water for future supplies, the availability of river water will eliminate the need to seek out or create costly reservoir and well sites. The other side of the water supply coin is the new uses, domestic and industrial, to which now abundant waters might be put. This society's experience has shown that the demand for resources always expands to match and then exceed the available supply. The simple fact of a new source of relatively clean water should not be construed as a new excuse for excess; that is the mistake past generations made in the first place.

Costs for providing other municipal services are likely to increase significantly, clean water or no. By themselves, the construction of sewage treatment plants will have little effect on the demand for fire and police protection, unless they stimulate second-generation population

increases in areas not requiring such service in the past. Perhaps the most significant impact that construction will have, is the method of financing chosen by the community. Using the usual grant application-federal and state aid pattern as a model, a community can expect to bear about 20%-25% of total construction costs. In cases like that of Lawrence or Manchester where the volume of flow is large and the component pollutants issuing from industries tied in with the municipal system can be complex and troublesome, total dollar outlay can run into eight digits. With a host of other services requiring attention just as urgently as water pollution control, the allocation of resources must be judiciously considered. Given no alternative, cities, towns, and industries, must bear the high cost of water treatment; and since construction costs rise on the order of 10%-12% per year they are well-advised to do so quickly.

Other municipal service impacts associated with the availability of quantities of clean water might include larger and more effective fire protection systems which could reduce domestic insurance rates, reduced maintenance costs for water delivery systems, etc. These effects, however, are so fine-grained that they would require detailed investigation and documentation.

3.10 Security

With this category, we begin to leave the impact classes which lend themselves to straightforward quantification. Short of the design of novel measures and on-site data collection, it is extremely difficult to determine with accuracy what the nature, range and duration of intangible changes like attitude may be. In this and the following four discussions of impact, the analysts rely upon first-hand but limited familiarity with the texture of public opinion. They make no claim to data analysis of any sort, and merely suggest areas in which further site-specific investigation is essential in Survey/Scope.

Few urban people think about the ways in which the raw materials of their survival -- food, water, sanitation, power, communication, etc. -- come to them. Still less do they consider the consequences of interruptions in the delivery of those necessities apart from the temporary inconvenience caused by unforeseen breakdowns and acts of Nature.

Therefore, it is not likely that the city dwellers in the Basin will take any note at all of the fact that a new treatment facility has provided them with better sanitary service or, ultimately, put new sources of clean water at their disposal. As a nation of people who have grown away from the natural environment, we take the stuff of life for granted. In the experience of this analyst, the construction of secondary treatment works has virtually no effect on the sense of well-being felt by the urban family. Until the day that the bathroom tap runs sewage, or, worse still, nothing at all, Mr. and Mrs. America remain oblivious and do not account themselves either fortunate or deprived.

If the installation of treatment works should come to have a high community profile -- say, as a result of a referendum vote or town meeting authorizing funds for site acquisition and construction -- citizens do become more aware of plant operation. In the sense that they are anxious to see their investment produce results, they can have a positive effect in watchdogging plant performance. Usually, however, the negative connotations of so mundane a municipal service as waste disposal are an effective deterrent to public interest or involvement.

3.11 Community Image

This is an area deserving of a man-year of study by itself. To do an exhaustive analysis of a community's own perception of role, purpose, and future prospects one should properly identify all the relevant actors, canvass them individually on a series of issues prepared in advance of any field work, survey the local communications media for citizen opinion (usually the exposed tip of the general attitude iceberg), and only then draw the most careful of conclusions. In terms of attitudes toward generic problems like water pollution control which cut across clear jurisdictional lines, the task becomes still more difficult. However, this analysis will venture some thoughts on (1) public attitudes toward the Merrimack River, (2) public attitudes toward pollution abatement in the river, and (3) public attitudes toward their role as citizens in that abatement procedure.

As Section 1.0 attempted to point out, Basin residents, or, more properly, urban dwellers, have little sensitivity for the Merrimack at all, save perhaps in the olfactory sense during low-flow periods. The

degradation of its waters has been so complete and of such long standing that the native population has ceased to expect anything of it whatsoever except, perhaps, that it be kept as far away as possible. Given that attitude, the impact that a clean river would have is certain; perhaps the best approximation of the indigenous population's reaction would be disbelief. That this river could be the source of any positive changes is outside the perimeters of reason for most people. We venture to say that until some tangible, preferably monetary, demonstration of utility could be supplied, the citizens of the industrial part of the Basin will remain skeptical of the benefits clean water might bring. People engaged in agricultural or recreation-related activities would be much quicker to appreciate the potential of a clean Merrimack. Even their enthusiam would turn on cost, however.

And that has direct bearing on their willingness to pay for abatement. In general, the relationships that most communities have had with water pollution control agencies at the state and Federal levels have been strained. Although the whole psychology of non-compliance deserves extended treatment and complete documentation in Survey/Scope, we can only suggest here that recalcitrance in and of itself is an indication that proximity to a clean water body is not a powerful motivational factor. Especially in communities like Lawrence and Lowell where the pain of past economic catastrophe is still deeply felt,and there is no shining industrial salvation on the horizon, the river is last on a long list of municipal priorities. Generally, citizens would be happy to accept whatever benefits might fortuitously emerge from a clean water program, but they are unlikely to undertake energetic abatement programs spontaneously.

Informed opinion generally holds that the impetus for pollution abatement must come from outside the Basin. It may be that the implementation schedules of Massachusetts and New Hampshire authorities can provide that impetus, but there are doubts. Although the track record for the state agencies charged with implementing treatment procedures has been commendable in terms of effort, actual construction in the Basin has not proceeded with the speed hoped for originally. With that in mind, there is little reason to hope that continuing down the same path -- applying ever more strict sanctions to discourage non-compliance --

will build plants any more quickly or, most importantly, change the negative attitude of the taxpayer toward the river he must pay to clean.

Precisely because he has been a disbelieving, even unwilling, actor in the pollution abatement scheme, the average citizen feels no kinship with the effort. If he lives in a small community, he does not understand why the treatment of that small municipal effluent should take priority over "the real big boys upstream". If he lives in an urban context, the dollar amounts associated with even minimal treatment discourage him, and he is likely to give his attention to other civic needs that impinge on him and his family more directly. The present approach of water pollution control authorities leaves little room for public involvement, save at the point when bills must be paid. There is no reason to assume that that syndrome will not continue in the Merrimack Basin for the duration of present implementation timetables.

3.12 Community Cohesiveness

In this area, too, present patterns may well continue uninterrupted. Except in situations where water quality and the construction of treatment facilities have become associated with larger political issues, they have not tended to attract general public attention, positive or negative. For the most part, the value of clean water is a consideration that seldom enters the mind of most citizens. When interest groups do form around the issue of pollution abatement, it is almost aways in terms of cost and benefit distributions. In cases where community finances are likely to be severely strained, the emergence of opposition groups is not at all uncommon. Usually, there are complementary efforts by other groups to push through a public works project that holds some promise of benefit; but in the face of other demands on the public purse, their efforts on behalf of principle are often in vain. Like school bond appropriations, water pollution control projects can stir deep feelings within a community and controversy can be hot, but lack of public debate is far more likely.

3.13 Citizen Involvement

It may be the very absence of that kind of public dialogue that makes the present administrative system for building abatement works

so unresponsive. Many community leaders are offended by the fact that they have little if any voice in the policy decisions that underlie their pollution control commitments. Many taxpayers, particularly the argumentative, litigious New England variety, are incensed at the "high-handed" tactics of the state and Federal agencies; numerous town meetings have repeatedly refused appropriate funds for even preliminary work on treatment facilities.

There is no reason to assume that the local share of anti-pollution costs will decrease under the present system. There is, in fact, a trend toward exerting new pressures on local jurisdictions to produce their portion of total expenditures more promptly. All this comes in the face of documented decreases in the local dollars forthcoming to match Federal shares. In 1960, local government invested $13.70 per Federal dollar in waste-handling works. By 1967, that expenditure had fallen to $5.20.*

Thus though the system becomes more locally oriented, it becomes more Federally dependent. The conflicts attendant on that contradiction are obvious and do not bode well for the future of the ultimate beneficiary -- the river itself.

3.14 Institutional Relationships

The legal, financial and administrative issues over which even the best-intentioned environmental management programs can stumble are legion. Communities have traditionally been uncooperative -- not only with supervisory state agencies, but particularly among themselves. The "good fences make good neighbors' approach to political life in New England has mitigated against even so obvious an alternative as united revolt.

The analysts see no opportunity in the present implementation system to teach communities the intangible value of acting in concert.

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*The Economics of Clean Water, Summary Report, U.S. Department of the Interior, March, 1970.

Still less is there a chance to take advantage of whatever benefits and economies might arise out of the physical integration of waste water flows and their treatment. Eventually, obstinate insularity will have to give way to more rational approaches to common goals. Just to give communities the option of cooperation would be a first small step toward more mature phases of interaction which might include regional economic planning. A river makes neighbors of many people. The time is long past when the mutual responsibilities of Basin cities and towns to one another should have prompted anti-pollution action. Environmental integrity is too serious and costly a proposition to allow petty competition.

Unfortunately, the present system does not encourage responsible behavior. Local jurisdictions faced with staggering financial burdens are offered sticks rather than carrots. Larger jurisdictions sharing a waterway (for drainage basins know nothing of state sovereignty)have no binding institutional structure in which to discuss and resolve differences. If a regional approach to wastewater treatment is, in fact, to be more than lip service to a good idea, the existing financial and administrative arrangements for water pollution control must be redesigned.

4.0 THE COALITION SCENARIO

4.1 Goals

The goals addressed by the unique partnership into which the U.S. Army Corps of Engineers and the Environmental Protection Agency have entered differ from those of the traditional approach pioneered by the Federal Water Quality Administration. First, in a strictly technical sense, the water quality standards suggested by the Corps are more stringent than those presently a matter of law. Tolerance levels for constituent pollutants will not be discussed here; the relevant Technical Appendix treats them in detail and makes their inclusion in this text redundant. Suffice it to say that the objective for the Merrimack River is maximum feasible water purity, limited only by the technological, economic, and social constraints identified in the course of the Feasibility Study.

Second, the time-phasing of construction would be markedly different if an Army-EPA coalition could become operational. The possible addition of heretofore untapped sources of Federal monies and a redistribution of tasks and costs on the state and local levels could materially speed the construction process of contemplated plants. Further, by undertaking construction in several locations simultaneously, a joint effort could actually hasten the day when the fruits of the investment required will become available to the public.

Finally, and most significantly, the philosophy of this wastewater management program represents a departure from the norm. First, the very concept of waste water has been called into question. It has been truly said that there is no more water on Earth today than there was at the dawn of time. The uses to which that water must be put, however, have increased exponentially over the span of Man's tenancy on the globe; he drinks it, washes in it, plays in it, uses it as a process component, and expects it to be available in abundance when and where he wishes. Until fairly recently it seemed that all those needs could be met, given

modern technology. As it turns out, water resources are far from inexhaustible; without using them more carefully, this nation alone will experience serious water shortages within a decade.

The most simplistic approach to that need for conservation and restoration is to clean up waste water discharges sufficiently to avoid degradation of the receiving waters into which effluent is discharged. That is a laudable goal and a monumental task on a basin-wide scale. If, however, we disallow the concept of "waste" water and view used water as a natural resource, instead, the act of treatment turns from a burden into new opportunity. For example, if a community in rennovating its water can make it do double or even triple duty by introducing it directly into its water supply or creating recreational water bodies it has extracted multiple benefits from its investment in treatment equipment. If industry in its pre-treatment of process water can reclaim other constituent pollutants as raw materials to be reused, it has at once aided the cause of environmental protection and pleased the stockholder who seeks production economies. It is precisely this reorientation of attitude that the Corps and EPA are investigating. Implicit in this new philosophy of resource management may be the tangible incentive to compliance so long absent.

Moreover, the coalition takes a regional approach to water management strategies. Although those active in the water field for many years have pointed out that the geographic and hydrological unity of river basins argue against the observance of jurisdictional lines, it has not been possible to coordinate the efforts of states and local governments effectively. With the emergence of joint Army-EPA projects, the prospects for successful cooperation among all jurisdictional levels grow more hopeful. New opportunities also come in the entirely new form of financial and institutional relationships among the many cities and towns sharing a watershed. Costs for water treatment and water supply can be shared more equitably. Water in an integrated system can be sent wherever it is needed, and in much the same way that electric power can be redistributed through

a regional grid. Coordinated regional planning for future water supplies can eliminate expensive competition among neighboring cities and towns for ground and surface water sources.

But, perhaps, most important is the notion that a water treatment system, even one that makes the water itself work harder for the people, should do more. The systems proposed by the Corps and EPA are multi-purpose designs. The treatment plants themselves, for example, are planned to be architecturally flexible. More than just innocuous, they can become dramatically attractive additions to the urban landscape which will stimulate the revitalization of now decayed neighborhoods. The planning of these facilities call for giving the public access to the shore, and still more importantly, access to the decision-making process which will allocate their resources and build their treatment systems.

4.2 Tools

The most immediately obvious way that the plans of the Corps-EPA coalition differ from those of the existing program is in the technologies they employ. Traditionally, the treatment of municipal sewage and industrial inflows has involved primary, secondary, and then tertiary treatment where necessary. The first part of that sequence performs largely physical cleansing operations on wastewater, screening, sedimentation, etc. Secondary treatment brings biological processes to bear on pollutants; cultured bacteria eliminate organic waste constituents in activated sludge operations. Tertiary treatment has generally been reserved for more sophisticated physical and chemical techniques which remove stubborn pollutants resistant to the primary and secondary treatment-flocculation, coagulation, ion exchange, carbon absorption, etc. Beyond refinements of process and the development of more efficient hardware, there have been no major technological breakthroughs that have been operational in the field. Many experts contend that the activated sludge process itself is outmoded and that new plants using that technique are no more than costly anachronisms. If their assessment is correct, then there is good reason to examine other technical alternatives.

The present implementation schedules of both Massachusetts and New Hampshire call for secondary plants which uniformly utilize the activated sludge approach.

The Corps-EPA coalition has evaluated other techniques, and the preliminary conclusion is that there are two which offer considerably more flexibility and are both feasible and attractive. The first is simply a better "black box." These are treatments called physical-chemical plants which perform on raw sewage all the purification tasks accomplished by primary, secondary, and tertiary treatment combined. Since other Appendices describe the technical aspects of the P-C process in detail, we shall not elaborate here. But, it is noteworthy from a socio-economic point of view that communities faced with complicated abatement problems may find that one P-C plant is far more attractive in terms of land use and financial planning than three separate facilities built over several years that accomplish no more.

The second innovative technology explored is the substitution of the earth itself for mechanical tertiary treatment. Again, the Technical Appendices are the appropriate source for detailed information, but the thrust of this approach is to apply effluent treated up to secondary levels - water cleaner by far than the present river water - directly to agricultural or forested land via spray irrigation or overland flow. The natural processes both physical and biological at work in the earth first renovate then recycle captured nutrients back into the biosystem.

From a purely technical point of view, both of these approaches are feasible for the Merrimack River Basin. However, there are many different ways in which they could be implemented; in tandem with activated sludge facilities, physical-chemical plants alone, land disposal alone. When combination schemes are contemplated, the permutations possible are many. The problem of selecting alternative approaches wisely is further complicated by simple facts of geography. For example, some areas of the Basin (either because they lack favorable soil conditions or are heavily populated) do not lend themselves comfortably to land disposal. In others, even where soils are adequate, the hydrology may not be favorable for the kind of underdrainage system planned to catch water cleansed through percolation.

Beyond the constraints of the physical environment, the new technologies must fit into the social and economic context which is the subject of this analysis. As Section 1.0 pointed out, it would be foolhardy to introduce any new technique, however attractive from cost or performance viewpoints, without careful evaluation of the socio-economic impacts it is likely to produce. The effort and expense required for any wastewater treatment project of the scale examined here disallows the luxury of a live-and-learn rationale. Section 3.0 set out what appears to be the likely series of changes precipitated by the existing implementation program; the following section performs the same task for the Corps-EPA approach. The discussion under each impact category focuses first on general impacts as they depart from the baseline scenario and then, where possible, treats individual solution schemes.

4.3 Impacts

4.3.1 Land Use

Clean water in the Merrimack River will change land use patterns and activity to some degree, whatever administrative or technical mechanism produces it. Although the impacts associated with the siting of activated sludge plants were not seen as being significant, the location and extent of the Corps' planned treatment works may well have pronounced effects.

Clearly, the in-migration of workers during the construction phase would be markedly larger for a program as ambitious as this one. Even if Scheme One (the building of nine activated sludge plants) were implemented, the mere addition of four regional tertiary plants would substantially increase labor demands. Thus all the effects of suburban growth associated with the present implementation schedule could be expected, but on an even larger scale.

Accessibility to the water's edge and recreation space would also be affected. Since treatment works in this approach are to be considered community assets and designed as such, the layout of plant sites is purposely generous to open new spaces for public access. In a crowded urban environment, this means that the construction of a much-needed water renovation facility could change the character of a dilapidated waterfront neighborhood. Since the Corps is considering plans to sink as much of the actual treatment machinery and tank systems below ground level, surface space could become part of, say, multiple-use open space. Attractively landscaped and well-maintained riverfront areas have, in the past, attracted new business and become the focal point for upturns in downtown commercial activities. Moreover, facilities may not have to be located immediately on the water's edge. Buildings housing process machinery could be used to separate existing incompatible land uses , for example, abutting residential and industrial areas. Further, regional physical-chemical plants (Scheme Two, Concord-Manchester, for example) could occupy up to 50 acres. In a sparsely populated area which could accommodate such a facility, the distribution of buildings and headworkd could stimulate clustering. Not inconceivably, new industry either

requiring large quantities of clean process water or discharging large flows of pretreated effluent could locate in immediately adjacent areas to take advantage of short transmission distances. With carefully controlled planning, the open character of rural landscapes which might otherwise fall victim to suburban sprawl could be preserved.

It is the land disposal alternative, however, which is likely to exert the most powerful effect on the future of land use development. First, if all wastewater flows in the Basin were to be renovated on land, a total of 79,000 acres would be required. Though composed of fragmented plots varying in size from 10 to 1000 acres, that total represents a substantial portion of the green land, forest and farm, near to urbanized areas. If the lagoon systems, settling ponds, flooding basins, and ancillary works were carefully laid out and first consideration were given to the concept of multi-purpose design, those acres would not necessarily be withdrawn from the supply of land accessible to the public or private industry. On the contrary, the system would function simultaneously to preserve the natural character of the land and integrate compatible land uses. For example, a nuclear-fueled generating facility might well utilize a water body created for treatment purposes to solve its thermal discharge problems, and at the same time provide space for recreational activities consistent with any seasonal irrigation operation. In the case of nuclear power plants, particularly, the isolation advantages of low-density areas are obvious. Quite apart from its primary water renovation function, the land disposal technology could stimulate regional economic planning in the Merrimack Basin.

Not only the facilities themselves, but the collection lines they service must be considered. It is not unreasonable to assume that wherever sewage lines go, housing development will follow. Well planned, this consequence may not be undesirable. However, the prospect of a proliferation of residential development in presently undeveloped areas is likely to meet opposition from local communities anxious to preserve the character of their towns. In sum, the land disposal alternative is a broad blade which cuts two ways: without strong, comprehensive controls on land use, it could destroy the landscape it seeks to serve.

Finally, land uses completely ignored by conventional techniques become possible with land disposal. The irrigation of cultivated farmland can, if practicable from a public health point of view, produce an upturn in a declining sector of the economy. This kind of impact is more appropriately dealt with in the Appendix concerning economic impacts, but it is also significant in terms of land use. If farming in the Basin continues to decline, it is likely that the land will fall idle and the people will migrate to urban areas to find industrial work. To the extent that irrigation techniques can reverse this trend, the indirect benefits of maintaining the land and curtailing further urban congestion would be considerable. This is not to say that the dollar productivity of agriculture would make it self-sustaining. In fact, there are sound reasons why farming as we know it has no place in modern New England. However, other factors like opportunities for those who wish to remain on the land or even return to it are powerful arguments for shoring up a beneficial, if not lucrative, economic activity.

For land areas presently in forest--and much of that acreage is part of existing farms--irrigation presents the opportunity for forest management activities. The national supply, and certainly the New England supply, of first growth timber is rapidly dwindling. Increasingly, lumber operators are hard-pressed to find straight stem trees which yield large quantities of defect-free board. The wood industries, in fact, are coming to rely more and more on composition board and other products produced from shredded common-grade trees as their first-line market offerings. However, there appears to be good reason for supposing that a market demand for solid wood of high quality will continue to exist; the public has not appeared ready to accept composition materials for items such as furniture, for example. Postulating that the call for high quality timber will prompt loggers to seek out new stands and pay premium prices, it makes sense to consider the possibilities of creating new supplies. In-forest disposal of treated effluent provides such an opportunity.

An expert forester with long experience in New England tree management reacted favorably to the suggestion that crews laying and maintaining in-forest irrigation systems might also perform forest management tasks.

In the opinion of Dr. John Noyes, University of Massachusetts, by merely clearing brush and cutting low branches on certain species, in a relatively short time it would be possible to make thousands of acres of "mixed New England hardwoods" commercially productive. It is likely that growth rates will be stimulated considerably by the nutrients in the renovated irrigant. That growth can be channelled in two ways. First, to produce height and straightness, small trees can be pruned of lower branches and induced to form a foliage canopy which discourages sunlight penetration and the formation of other defect-producing limbs. By making small trees "reach for the sun," even minimal management could produce significant numbers of straight butt hardwoods and conifers. Second, by selective thinning, which ends strictly heliotropic effects, and variation of irrigant nutrients, girth can be stimulated.

After a period of some 25 years, the end result is supplies of prime quality lumber produced by forest land which would otherwise have remained untended or destroyed to make room for new population or industry. Over that time period, a low-cost labor intensive activity has absorbed considerable numbers of unskilled workers or outdoor enthusiasts.

From the point of view of land use patterns, so simple an adjunct to the mechanics of a wastewater treatment system could not only preserve the forest cover, but improve it to the extent that it would become aesthetically and even economically desirable to keep the land in trees. The example of Northern Europe in careful tree management demonstrates that the concept is a viable one. Its economic and institutional implications are discussed below in the appropriate categories.

4.3.2 Population

As with land use patterns, population trends depend largely upon the magnitude of future commercial activity. In the short run, the Corps approach can be more productive of jobs for the unskilled worker - the verylabor resource in which the Basin is richest. If construction activities for any scheme could be initiated simulatneously or even time-phased seriatim, they might well draw population even from outside the Basin. If the duration of such work were better known we could make some crude estimates of the likelihood of immigrants settling down permanently. As it is, one cannot say with certainty that significant increases in permanent population attributable to system construction would occur.

With impacts connected to a new availability of clean water, however, one can generalize more comfortably. If the conventional treatment systems would make stretches of the attractive river for non-contact water activities, then the "maximum feasible purity" goal of the Corps could only offer further benefits. Recreational opportunities are clearly the first to materialize. Population mobility patterns will, over time, show a tendency to bring new residents to areas where the natural environment is most pleasant. The estuary and the Winnepesaukee region, for example, already demonstrate that phenomenon. Thus, just by itself the Merrimack could become a focal point for inmigration without respect to employment, though the numbers of those who could afford long commutation to jobs in the Boston area, or become self-employed, are limited.

More likely is a long-term population increase generated by the location of new industries in the Basin. Though speculation on the nature of the industries seems risky, one can safely assume that the availability of inexpensive, local labor, and rising property taxes in metropolitan areas alone, make the lower and middle Basin attractive for relocation. Clean water, of course, would make the region that much more desirable to industry requiring high-quality process water. If the Corps alternatives (in any combination) could produce rapid water improvements, and establish the area as one of revitalized economic activity, they could precipitate desirable population increases more quickly than the conventional program.

Finally, the land alternative for wastewater disposal is extremely interesting of itself, regardless of clean water impact, because it focuses intensive activity in the countryside. Population trends for more than a century have been away from the soil and toward urban agglomerates. Out-migration from rural areas in the Merrimack Basin has been particularly pronounced. The land disposal technology and its concomitent agricultural and forestry potentials might hold the line on population decreases in rural areas and relive growing pressures on urban areas already hard-pressed to serve present residents adequately. In this sense, a water treatment system could - over the long term - hold population density in Basin cities at desirable levels, counter the steady pattern of depopulation in rural areas, and allow more time for more informed decision-making on the direction of future growth.

4.3.3 Municipal Finance

Trends in municipal spending are even more difficult to predict with accuracy than population, because there has been no overt consideration given to the ways in which the projects associated with the Army-EPA coalition might be financed. It is at least certain that there are alternatives, for any regional waste management project as ambitious as this one is unlikely to succeed without innovative financing techniques. The costs even of the existing implementation scheme are substantial, and it does not appear that the present tri-partite federal-state-local funding arrangement would suffice. The burden on local communities is simply too great, particularly if significant improvements in water quality were to be made within the 1970-1980 decade. Given the increasingly loud complaints from local jurisdictions about water pollution abatement costs and priorities--complaints which frequently ripen into outright non-compliance--a more equitable distribution of expense, perhaps in proportion to waste loading of a waterway, is unavoidable, whether the Corps becomes involved or not.

The possibility of that involvement does introduce interesting new opportunities, however. Most obviously, if site acquisition and construc-

tion financing could be handled through a single regional authority, local jurisdictions could realize substantial savings in dollars and time. The waste acceptance authority created last year in the State of Maryland, for example, seems to be an extremely effective administrative tool. Although its operational time has been short, the Maryland Environmental Service could be evaluated and its structure adapted to the needs of the Merrimack Basin. Moreover, not only the mechanism for financing, but the actual commodity offered the investment market bears reexamination. For example, might a regional bond bank modelled on the public instrumentality created by the Vermont Legislature in 1969 enable Basin communities to place their municipals more advantageously? Perhaps this regional project presents the ideal opportunity for the design of an entirely new form of bond, one which, like the Series E type, is accessible to the small investor but has the attractive tax features of municipals.

Beyond new long-range possibilities for cost savings, cities, towns, and the two states concerned could benefit from the substantial input of start-up money suggested by the involvement of the Army Corps. Whether or not it is justified in its belief, the public conceives of the resources concentrated in the Defense as virtually inexhaustible. Many citizens, in fact, have brought constituent pressure to bear on their Congressional representatives to work for the reduction , or at least the redirection, of military spending. Considering, too, the fact that the Corps is generally well-regarded in the Merrimack region (an effect of Army flood-control activities initiated after the disaster of 1938), the arguments made by the public in favor of giving the Engineers this opportunity to "hypo" a pollution control effort are powerful ones. If it can be demonstrated to local officials that their investment buys better pollution control techniques, more quickly, and at no inordinately greater cost in a regional management scheme, these arguments become irresistable.

Also to be considered in advance of a decision to employ land disposal methods are the implications for the future of local tax bases. If, for example, large quantities of urban waterfront land or semi-rural acreage likely to attract future housing or indistrial users were withdrawn from the taxable

sector, local communities might well suffer. To avoid unfavorable strictures on the growth of local economies, it seems reasonable to consider the easement approach to land access rather than outright acquisition by the Federal government. Were titles to remain in the hands of present owners, for example, and some portion of their property taxes contributed by the Regional Authority to town or city coffers, the chances of successful implementation would substantially increase. Naturally, the increases in assessed valuation associated with improved water quality generally and discussed above in Section 3.4 would apply.

4.3.4 Commercial Activity

Generally, the prospective impacts of Corps-EPA treatment schemes for local economies would be no different in kind than those associated with the present implementation program. However, higher demands for goods and services would be almost certain to occur at least during the construction phase; the large scale implied might predictably produce such effects more quickly and for a longer period. Over a longer term of perhaps a decade, the effects of any business displacement caused by site acquisition for plants could be erased by carefully planned relocation measures and the advent of new industry drawn into the Basin by clean water, labor supply, tax benefits, etc. In rural areas, the upturn in agricultural productivity presaged by initial irrigation successes combined with the forest management described under Land Use could well change the present imbalance of economic activity between low and high population density areas. What the effect of that change could mean is beyond the scope of this cursory examination and requires careful consideration in Survey/Scope.

One possible impact more positively associated with the coalition plans than with the existing program is the stimulus that the implementation of new technology will have on the suppliers and manufacturers of anti-pollution equipment. As a report prepared for the Massachusetts Department of Commerce and Development points out, approximately 22 manufacturers of specialty water and air pollution control equipment are located in Massachusetts. Of the top 11 suppliers of instrumentation, moreover, the

fourth-ranked is a Foxboro, Massachusetts concern which, with the three front-runners, accounts for nearly 40% of the national market sales.

Thus, a large, sustained demand for treatment components could excite corporate and municipal economies both in the Basin and beyond. Especially in light of the slow-downs along the Route 128 complex and the availability of technical talent, it seems an opportune time to consider a massive construction program which will promote intensive industry action. Moreover, by utilizing unconventional physical-chemical plants on a large scale, the Corps would certainly make substantial contributions to the state of the water treatment art.

4.3.5 Housing

Impacts in this category are much the same as for the existing program, were it to be universally and quickly implemented. As with economic activity, the larger scale involved can be assumed to produce proportionately larger demands. In terms of increased activity in the suburban fringe, the discussion presented under Land Use suggests that the land disposal alternative might restrict total acreage available for expansion. That is not necessarily a limitation on the number of people which can be accommodated, since high-density clustering á la new towns is consistent with the adjacent location of treatment plants, industries, and abundant clean water supplies.

4.3.6 Education

Again, tied directly into changing population patterns of number and density are demands placed upon existing public school facilities. The qualitative impacts of the coalition approach to regional wastewater renovation are not seen to be different from the impacts expected over time with the EPA strategy alone. In terms of quantitative needs for classroom space, faculty, and bus transport, however, the implementation of advanced treatment techniques and the ultimate availability of volumes of clean water may, by attracting larger populations, create a larger demand more quickly. At least in theory, those shocks to existing school systems and school plants could be partially sustained by structures suited to multiple-use purposes.

The most outstanding way in which the coalition plan offers opportunities unavailable under present implementation schedules is in the multi-purpose design of the facilities themselves. Because the very philosophy of a new approach turns on generating maximum benefits per investment dollar, these plants are calculated to produce not just maximum feasible water quality but also positive second generation social impacts. In the education area, that can mean that buildings housing water renovation equipment could also be used for public purposes, education among these. For example, if environmental education or laboratory-oriented curricula were to be concentrated in water renovation facilities, the need for expensive new construction used only during the school year would be eliminated.

4.3.7 Leisure Opportunities

If clean water produced by the successful and timely completion of present implementation schedules were seen to have widespread recreational impacts, so much greater are the positive changes associated with the coalition strategy. First, more total water area suitable for water contact activities would be created because the maximum water quality feasible would have been achieved. That implies that not only stretches of the Merrimack now classified at high levels would become accessible to the public--those areas being concentrated chiefly at the extreme northern and southern end of the Basin--but that reaches flowing through intensely industrial areas would also permit water activity. For urban areas which most acutely feel the need of recreational space for citizens of every age, that advantage is not trivial.

Terrestrial recreational opportunities also expand with a coalition approach, because water disposal facilities would be larger and able to accommodate greater numbers of visitors. More importantly, however, the land disposal techniques would open recreation sites in rural areas not contemplated at all by the present plan. By implication, a more heterogeneous population could be served outside immediate urban areas and a greater total acreage would be available to absorb demand.

Recreational impacts are particularly important, because they are the ones most quickly realizable. They are closest to the public eye and serve as

an almost immediate demonstration of benefit for investment. The partnership approach has distinct advantages over the present plan because it distributes those benefits more evenly. Not only is that geographically elegant, but it can avoid the traditionally bitter inter-jurisdictional disputes between polluters unwilling to subsidize benefits felt elsewhere. In classic economic terms, the new approach internalizes desirable externalities and returns to those who bear cost, proportional returns. In this connection, it cannot be too strongly emphasized that it is not technologies alone that permit such desirable effects, but their integration with complementary administrative and financial strategies of regional management.

4.3.8 Cultural Opportunities

Without specific siting data, it is impossible to determine the number and kind of institutions potentially displaced. Logically, it is also impossible to calculate dollar costs for moving or replacing such structures. This kind of fine-grain analysis must be site-specific and utilize data collected in the Survey/Scope phase of this study.

On a more general level, it is possible to suggest that the revitalization of decayed urban waterfronts might change the value scale on which existing structures are judged by local residents. In Urban Redevelopment Project areas, that short-term impact could mean that "old" buildings could become "antique," and retained rather than razed. In a river city like Newburyport, for example, an enhancement of shoreline property by imaginative and attractive public works structures would only reinforce existing trends toward an upward reassessment of local historiana. People drawn to the river become a likely service population for maritime museums, craft shops, and historic sites.

4.3.9 Transportation

In general, impacts on transportation as it relates to employment, commerce, education and recreation are basically the same in kind for both approaches to water renovation. For the most part, differences are incremental quantities in numbers of commutation trips, haulage, common carrier trips, school busing, and tourist visits.

Land disposal, however, does introduce new considerations. For example, if extensive acreage in now rural areas were to receive effluent applications, access for equipment installation crews would be required. Poorly managed, provision of that access with new roads could scar the countryside. With careful inspection of the areas to be served, however, it may be possible to simply use existing rights of way. Abandoned rail lines, old logging roads, and now inadequately maintained private access routes could eliminate the needs for costly new road-building. In certain areas, the laying of irrigation pipe on the forest floor, since it appears to require only minimal brush clearing, could open access routes to controlled numbers of outdoor enthusiasts.

Although it is extremely difficult to speculate on the disruptions in transport linkages the building of any public works project might have without specific location data, it is probably safe to assume that some present routes of access will have to be changed or replaced entirely, Date collected in the Survey/Scope phase will be the source of detailed information required to plot existing connectors and do intelligent planning for minimum dislocation and inconvenience.

4.3.10 Municipal Services

Since the coalition approach considers water treatment essentially a resource reallocation exercise, rather than disposal of an undesirable product, water quality will be markedly higher than with conventional approaches. That means that the quality, as well as the quantitive of water available for domestic and industrial use, can serve as inducements to change. Drinking water supplies can profit directly and quickly from advanced renovation techniques which make ground water recharge or even direct introduction into feeder systems possible. Industrial users will also profit from higher water quality because processes, otherwise precluded will become practicable. Considerations of quantity are significant too, because future sources exclusive of the river are scarce and costly to develop. Even if population increases are only modest local supplies presently available will not be able to keep pace with demands. In the opinion of some experts, in fact, pollution abatement is basic to water supply requirements as imminent as 1980.

From a more practical point of view, the operational costs of providing the public and industrial users adequate water could be substantially reduced if water inputs to municipal systems were higher in quality. Corrosion and other effects harmful to pumping and transmission equipment could be virtually eliminated if uniformly high water quality could be assured. Moreover, expensive pre-conditioning-like filtration and removal of impurities that disrupt industrial processes would become unnecessary.

Most interesting, however, are the opportunities opened by a regional approach itself. For example, to achieve economies in sludge incineration, it might well be wise for a wastewater treatment system to include some solid waste management in its operations. To a city or town, that would mean that double duty could be done by a single facility and the need for an independent incineration plant for sorted garbage or expensive transport to a regional plant could be avoided. This kind of multiple-service also offers impressive strategic benefits; the more services offered a community, the more trade-offs appealing to local interests can be worked. Since interjurisdictional cooperation is

crucial to the success of a regional approach, the ability of a city to exchange supply lines much needed in a suburban development for solid waste disposal is by no means trivial.

4.3.11 Security

As stated above in Section 3.10, the public at large feels little kinship with the systems that supply it with the essentials like water, power, sewage collection, etc. Until there is a service disruption, the fact that those systems even exist is not a matter of concern. Therefore, it is unlikely that the availability of new water resources or more efficient resource handling will have much of direct impact on the public's sense of security. More likely to directly affect the citizen's perception of security are second-generation impacts like the increased police protection and better lighting associated with the presence of large public facilities. In a decayed downtown area, perceptible decreases in the number of reported crimes in the area of a large around-the-clock water treatment operation are likely. Other changes related to security may stem from the expansion of municipal water service and fire protection to outlying areas previously dependent upon nearby natural sources.

4.3.12 Community Image

In terms of impacts measurable in dollars, a general rule of thumb which seems applicable, will be increases in the value of property along the river and slight decreases in values for land immediately adjacent to treatment plants. Of course, this rule is only as good as the wisdom with which it is applied. Conditions will vary greatly from site to site, and the direction of short-term trends may change over time. Moreover, internal differentiations must be considered. For example, it is likely that increases in shorefront values will be more rapid in areas outside the immediate urban core, since residential markets are likely to be more responsive to clean water effects. Where there are estimates of public traffic as with commercial enterprises, responses may be more cautious and upturns slower in coming. Both the treatment facilities located in urban environments and land disposal works will predictably depress the desirability of abutting land over the short term, but it is possible that as local economic conditions stabilize and if fears of undesirable effects remain unsubstantiated, values will rise.

In terms of intangible impacts, it is aesthetic considerations that probably take precedence over all others. The generally negative impression the public has of waste treatment facilities will require powerful counters. If imaginative uses for renovated water are implemented, for example, local attitudes toward sewage treatment works will change more quickly. Renovated water, instead of being pumped directly into river receiving waters, could pass through a series of fountains in riverfront park and be channeled in a kind of urban waterfall back to the river. In this way community pride and a sense of satisfaction with the public investment in treatment facilities is heightened.

4.3.13 Community Cohesiveness

Since any public undertaking of this magnitude is liable to excite public interest and attention, it is safe to speculate that community cohesiveness will be disrupted. In one sense, that disaggregation of local groups is undesirable, In another, it is healthy and stimulates the kind of debate often impossible in communities were there are no exchanges of views at all. Clean water in the Merrimack - regardless of the who and how of improvement - will generate negative opinion. Thus, knowing that all interests cannot be satisfied completely, policymakers should not hesitate to make use of whatever unconventional techniques appear useful, as long as they work toward an equal distribution of cost and benefit.

Quite apart from the local level are opportunities for regional cooperation impossible under the existing program. Communities arrayed on implementation schedule sheets are immediately made adversaries, each seeking either to avoid compliance completely or to win concessions that will minimize cost and produce the largest local benefit. That kind of insular thinking is out of phase with times when people are becoming ever more interdependent. The coalition scheme, on the other hand, with an equal measure of persuastion and coertion could initiate an "Era of Good Feelings" in the Basin and promote a sense of regional community long overdue. What formal administrative mechanisms would best serve that purpose are not known, but Survey/Scope must not overlook their investigation.

4.3.14 Citizen Involvement

Expressions of public opinion are made at two levels in a local community; through the formal governmental structure, mayor, selectman,

or city manager, and by individuals or groups through the local news media. As Section 3.13 pointed out, the track record of the existing abatement program with the first of those actors is not satisfactory. A cumulative backlog of more than forty-three years in meeting treatment obligations in Massachusetts alone is indicative of the kind of hostility built up between supervisory state agencies and town governments.

If official relationships have been strained, contacts with individuals have been infrequent at best, and seldom in advance of decisions on siting or financing. On one hand, state officials have dealt directly with local officials and left to them the arrangements of local compliance. Local officials, save in the few cases where referenda are required by statute, have usually worked unilaterally and made no provision for accomodating popular opinion. A carefully designed program of citizen involvement, however, could in many cases have avoided after-the-fact acrimony and costly delay.

Precisely because its scope is so large and so many interests will be affected, the EPA-Corp plan depends heavily upon citizen participation. That means that the public will become involved in the planning processes which ultimately spend their money. The information-sharing required to make that involvement meaningful cannot help but improve relationships among governments and interest groups. The challenge in centralization of authority is to make its power clearly derivative; local communities must feel secure enough in their purpose and administration to surrender a portion of their previously sovereign powers willingly. That can happen only if individuals and groups are given the opportunity to be heard.

4.3.15 Institutional Relationships

The EPA-Corps partnership is liable to have an extremely large impact in this area because it cannot even contemplate operationalizing its plans without designing a new administrative structure in which to carry them out. That design must necessarily consider all the present institutional actors - state and local governments, regional groups, Federal agencies, and private interests - and weigh their present roles and capabilities. Since, in the opinion of many political observers that kind of re-examination is basic to better government, this regional water management approach

is a convenient and timely opportunity to better order public agencies and policy. Research performed in Survey/Scope should have as its objective the design of an administrative structure acceptable to the majority, responsive to the minority, and yet strong enough to accomplish its mission without bias to either.

5.0 SCHEME EVALUATIONS

With the foundation established by Sections 3.0 and 4.0, this analysis will now venture opinions as to how individual schemes might produce social impacts. As before, it is not possible to speak in specific terms without having had rigorous data. The objective here is simply to offer hypothesis appropriately tested in the Survey-Scope phase of this study. Matrices and descriptive evaluations for each scheme follow in Sections 5.1 - 5.8.

MATRIX KEY:

√	= significant impact (change)
○	= minimal or no impact (change)
↑	= upward trend
↔	= stable
↓	= downward trend
+	= positive effect
−	= negative effect
N.A.	= data not available
L-L-H	= Lowell - Lawrence - Haverhill
F-L	= Fitchburg - Leominster
N	= Nashua
M	= Manchester
C	= Concord
W	= Winnepesaukee

5.1 **Scheme #1; E.P.A. Program Alone/Water Disposal**

	L-L-H	F-L	N	M	C	W
Land Use	√ ↔ —	√ ↔ —	√ ↑ +	N.A.	√ ↔ +	N.A.
Population	√ ↓ —	√ ↓ —	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↓ — / √ ↓ —	√ ↓ — / √ ↓ —	√ ↑ + / √ ↓ —	√ ↑ + / √ ↓ —	√ ↑ + / √ ↓ —	√ ↑ + / √ ↓ —
Housing Supply	o ↔ —	o ↔ —	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Education	o	o	o	o	o	o
Leisure Opportunities	√ ↔ —	√ ↔ —	√ ↔ —	√ ↔ —	√ ↔ —	√ ↑ +
Cultural Opportunities	o	o	o	o	o	o
Transportation	o	o	o	o	o	o
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	o	o	o	o	o	o
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↓ —	√ ↓ —	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Citizen Involvement	o	o	o	o	o	o
Institutional Relationships	o	o	o	o	o	o

Scheme #1 suffers from several defects. Evaluated first for its potential to achieve higher water quality, it is markedly less ambitious than the other strategies. Moreover, though the system is by now familiar to local jurisdictions, its administrative features require overhaul; non-compliance with existing implementation schedules is all too common in this Basin. From a technical point of view, its complete reliance on the activated sludge process is unfortunate. The technology is a very old one and the wisdom of sinking millions into large new facilities vulnerable to biological toxicants seems questionable at best. Further, the plan makes no mention of tertiary treatment, a virtual necessity if the Merrimack is to become a major source of public water supply, and does not come to grips with the issue of proper sludge disposal.

Neither is the plan without its merits. First, it would bring to the river a measure of cleanliness unknown for over a century. The people immediately adjacent to the water would unquestionably profit from the recreational and perhaps even industrial possibilities opened by careful plant operations. Then, too, the system for building the required plants is a familiar one to local officials; they are comfortable with applications for construction grants, state aid, etc. If the implementation schedules managed by the States of New Hampshire and Massachusetts can be met on time, the entire Basin would be the better for its investment.

However, the most important shortcoming in this strategy is that the initiative for compliance still rest entirely with local government and only legal sanctions exercised by the State can stimulate action. The system seems outmoded because its only power is coercive; persuasion and incentive, if of no avail, lead only to legal enforcement proceedings. A more productive administrative structure would be responsive to the pleas of cities and towns genuinely unable to comply, and ready when necessary to preempt construction responsibilities and abate polution unilaterally. At present, the system shows little flexibility, disallowing serious regionalization and operating on what many think to be backward priorities.

5.2 Scheme #2; CORPS - E.P.A. Program/ Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	✓ ↔ +	✓ ↔ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Population	✓ ↑ −	✓ ↑ −	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Commercial Activity / Municipal Finance	✓ ↑ − / ✓ ↓ −	✓ ↑ − / ✓ ↓ −	✓ ↑ + / ✓ ↓ −	✓ ↑ + / ✓ ↓ −	✓ ↑ + / ✓ ↓ −	✓ ↑ + / ✓ ↓ −
Housing Supply	✓ ↔	✓ ↔	✓ ↑ +	✓ ↓ −	✓ ↑ −	✓ ↓ −
Education	0	0	0	0	0	0
Leisure Opportunities	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Cultural Opportunities	0	0	0	0	0	0
Transportation	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Municipal Services	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Security	✓ ↔	✓ ↔	✓ ↔	✓ ↔	✓ ↔	✓ ↔
Community Image	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Community Cohesiveness	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Citizen Involvement	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Institutional Relationships	✓ ↔	✓ ↔	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +

The CORPS - E.P.A. plan built most closely on the existing program suffers from only one of its defects; the dependence on the activated sludge process. Again, in the lower Basin where a high concentration of industrial waste flows is to be expected, the biological sensitivity of these plants argues against their use.

Like all six other coalition schemes, this one incorporates surface and sub-surface stormwater storage basins in its design. Since storm runoffs constitute a pollution problem quite as serious as sewage, provision for collection and then controlled treatment and discharge is extremely important. The inclusion of two physical-chemical plants (Manchester and Winnepesaukee) would allow New Hampshire to utilize an innovative technology suited to areas likely to experience accelerated growth and higher volumes of flow. To produce maximum feasible water quality, this scheme would not require regionalization below the tertiary level. To cities and towns long accustomed to insular thinking and uncomfortable with cooperative municipal efforts, that would be reassuring. More important, Scheme #2 would not undo any site or design plans already in the state pipeline.

Further, because the product of treatment would be of very high quality, it could be introduced directly in municipal and industrial water supplies and eliminate the need for costly searches for terrestrial supplies. Flow augmentation alone in the L-L-H and F-L sub-regions would greatly improve the appearance of the river and put a new premium on shoreline property.

The principal constraint on implementation, however, is the suggestion that renovated water be exported to Southeastern Hew Hampshire or to the Boston Metropolitan area. If the cities and towns of the Basin were to make the necessary expenditures and construct the plants called for in this scheme, it is extremely unlikely that they would suffer the fruits of their industry to go elsewhere. Even in the face of freshwater inputs to the Basin in exchange, the people of Manchester and the lower Basin at Lowell, Lawrence and Haverhill will want to see and touch and spend the benefits they buy.

The principal merit of this and other CORPS - E.P.A. alternatives is in the potential for developing new administrative and financial mechanisms for pollution abatement. Even without extensive regionalization, a more equitable distribution of costs and benefits could only help cities and towns with abatement responsibilities.

5.3 Scheme #3: CORPS - E.P.A. Program/ Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	O	√ ↑ +	√ ↑ +	√ ↑ +	O	√ ↑ +
Population	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↑ + / √ ↑ +	√ ↑ + / √ ↑ +	√ ↑ + / √ ↑ +	√ ↑ + / √ ↑ +	√ ↑ + / √ ↑ +	√ ↑ + / √ ↑ +
Housing Supply	↔	↔	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Education	O	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Leisure Opportunities	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Cultural Opportunities	O	O	O	√ ↑ +	√ ↑ +	O
Transportation	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	√ ↓ −	√ ↑ +	√ ↓ −	√ ↓ −	√ ↓ −	√ ↑ +
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Citizen Involvement	√ ↑ +	O	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Institutional Relationships	√ ↑ +	O	√ ↑ +	√ ↑ +	√ ↑ +	O

This scheme is the same as the first E.P.A. - CORPS offering in that it leaves the provisions of the existing implementation schedule undisturbed. It differs because it integrates the Nashua sub-region with Lowell-Lawrence-Haverhill, using a single regional tertiary plant to treat the effluent of their five several activated sludge plants. Without cost data it is difficult to estimate what economies of scale are realizable for the taxpayers of those cities, or for residents and industries in Manchester and Concord, integrated sub-regions served with a single physical-chemical plant. However, experience suggests that cost-sharing could be mutually advantageous.

Cost-sharing on the local level bears further investigation in the Survey/Scope phase since interstate jurisdictions are involved. Whereas Manchester and Concord, as New Hampshire cities, could cooperate in building abatement facilities without serious legal impediments, such may not be the case for the Massachusetts cities and Nashua, across the border. Without serious research into the institutional issues raised by their partnership, it is difficult to judge the real-world viability of Scheme #3. A new regional political entity with the appropriate powers may be necessary to remove jurisdictional barriers to cooperation.

5.4 Scheme #4: CORPS - F.P.A. Program/ Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Population	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↑ + / ↔	√ ↑ + / ↔	√ ↑ + / ↔	√ ↑ + / ↔	√ ↑ + / ↔	√ ↑ + / √ ↑ +
Housing Supply	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Education	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	0
Leisure Opportunities	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Cultural Opportunities	√ ↑ +	0	↔	√ ↑ +	↔	0
Transportation	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Citizen Involvement	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Institutional Relationships	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +

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If regional integration presented problems in Scheme #3, Scheme #4 could prove even more troublesome. Here there are but two Environmental Management Areas for the entire Basin; Lowell-Lawrence-Haverhill + Fitchburg-Leominster + Nashua and Manchester + Concord + Winnepesaukee. The case against the probability of achieving that degree of regionalization even on just a political level is a strong one. Though the technology suggested is superior to the usual activated sludge process, the long transmission lines proposed may prove costly, both in terms of construction and maintenance and possible undesireable land use changes along their routes. Of course, long lines might prove to be an economy since new developments both industrial and residential would be able to tie in at minimum cost. To avoid the worst effects of suburban sprawl, the regional authority administering the implementation of this or any other plan should be armed with land use planning powers to channel growth.

Such a high level of regionalization might not enjoy the public's confidence in terms of plant reliability. Sound arguments can be made against a system which could produce regional disaster if it failed. Moreover, the concentration of huge volumes of renovated water at just two points seems unwise, not only in terms of security for neighbors immediately downstream, but in terms of distribution. Local low flow augmentation, so badly needed in Fitchburg-Leominster, for example, might be precluded without retransmission. Generally, the options for local use are much broader if renovation is performed nearer the source of water use.

5.5 Scheme #5; CORPS - E.P.A. Program/ Land Processes

	L-L-H	F-L	N	M	C	W
Land Use	O	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ −
Population	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −
Housing Supply	O	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Education	O	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Leisure Opportunities	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Cultural Opportunities	O	O	√ ↑ +	√ ↑ +	√ ↑ +	O
Transportation	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	O	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Citizen Involvement	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Institutional Relationships	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −

This scheme is particularly interesting because it brings into play an unconventional medium for water treatment, the land itself. By substituting lagoon systems to do the work of secondary treatment and spray irrigation or overland flow to perform tertiary treatment, the construction of large abatement works in down town areas is eliminated. In one sense that might be desireable, leaving shoreline property which will increase in value available for private development. In another sense, however, it may be a city's loss not to have treatment plants of the multi-purpose design proposed to spearhead downtown rehabilitation. Further, with treatment works moved into the countryside, extraordinary precautions against the destruction of the landscape must be taken. That burden can only be borne by a regional administrative authority with considerable land use zoning powers; the surrender of zoning rights by local jurisdictions may prove impossible.

The land disposal alternative requires large amounts of land, perhaps too much to make continued growth of the middle Basin as rapid as local people would like. On the other hand, with careful management, land disposal could create a new ex-urban environment which at once permitted vigorous economic activity (industrial and agricultural) and still preserved the character of the landscape. The possibilities of intensive forest management and increased agricultural productivity opened by irrigation are attractive, though the export of effluent to Maine from the lower Basin seems a difficult solution. Most seriously in doubt, however, is the ability of the land to sustain continued application of such vast amounts of water over time without damage. The ecological disaster which would be visited on the entire Basin by miscalculation or necessarily imperfect knowledge makes caution the first consideration in evaluating this scheme. Even though the loss of dollars invested in building the systems for each sub-region would be enormous, they could not compare to the costs of ruining much of eastern New England.

Public acceptance of land application would be a product only of carefully presented public education programs. The prevailing attitudes toward waste would have to be reeducated; wastewater must become a valuable resource in the public mind before it can go on the land.

5.6 Scheme #6: CORPS - E.P.A. Program / Land-Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	√ ↔ +	√ ↔ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Population	√ ↑ −	√ ↑ −	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↑ − / √ ↓ -	√ ↑ − / √ ↓ -	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ -	√ ↑ + / √ ↓ -	√ ↑ + / √ ↓ -
Housing Supply	√ ↔	√ ↔	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Education	0	0	√ ↑ +	√ ↑ +	√ ↑ +	0
Leisure Opportunities	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Cultural Opportunities	0	0	√ ↑ +	√ ↑ +	√ ↑ +	0
Transportation	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	√ ↔	√ ↔	√ ↓ −	√ ↓ −	√ ↓ −	√ ↔
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Citizen Involvement	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Institutional Relationships	√ ↔	√ ↔	√ ↓ −	√ ↓ −	√ ↓ −	√ ↑ +

This approach combines the water treatment techniques of Scheme #1 and the land treatment techniques of Scheme #5. It eliminates the problem of long transmission to suitable land areas from the Lower Basin by using land disposal techniques only in the Manchester, Concord and Nashua sub-regions where receptive soils are more proximate. In the Winnepesaukee area, water disposal is attractive because land is likely to become very valuable and irrigation areas would be closed to the public for some period during the summer months. In the middle Basin where population influxes will not be so seasonal or so rapid, the lagoon systems and the irrigation of forest and farm are more practical. The same caveats on overloading soils and the potential for environmental destruction apply here as in Scheme #5, though primary effects would be confined to the Nashua, Manchester, Conrord area.

5.7 Scheme #7; CORPS - E.P.A. Program/ Land-Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Population	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Commercial Activity / Municipal Finance	✓ ↑ + / ✓ ↑ +	✓ ↑ + / ✓ ↓ +	✓ ↑ + / ✓ ↑ +	✓ ↑ + / ✓ ↑ +	✓ ↑ + / ✓ ↑ +	✓ ↑ + / ✓ ↑ +
Housing Supply	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Education	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Leisure Opportunities	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Cultural Opportunities	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Transportation	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Municipal Services	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Security	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Community Image	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Community Cohesiveness	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Citizen Involvement	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +
Institutional Relationships	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +	✓ ↑ +

This scheme offers the greatest flexibility of the eight. In each sub-region the division of water renovation labor would be seasonal -- that is, water treatment in the winter months and land application during warm weather, save in the Lowell-Lawrence-Haverhill area where water techniques would be used year-round. This scheme is attractive from a number of different points of view. First, it does not require regional integration and sidesteps at least a portion of the institutional conflicts that might arise. Second, it conforms in large part to the existing implementation schedules' distribution of secondary plants. Physical chemical facilities are planned only in Nashua, Manchester, and Winnepesaukee, the latter two having no present provisions for treatment. Third, by applying effluent to the land during the summer months, this scheme allows for the maintenance of tertiary/physical-chemical plants during down-time. Regular repairs could save considerable expense and minimize the possibility of plant failure.

Most importantly, this scheme utilizes the land alternative in more measured proportion than any other scheme. While all the benefits attendant on land application could be realized, the burden on local environments would not be so great, and a quick response to unfavorable indicators of environmental stability would be possible; water renovation would always be an available option.

The same problems of public acceptance for land application obtain, however. In many ways the obligation to inform and involve the public is not merely a burden, though. It can be an extraordinary opportunity to give citizens the voice in pollution abatement so far denied them. This scheme seems to combine the right elements of innovation, public involvement, maximum water quality, and local autonomy without doing real violence to the existing program.

5.8 Scheme #8: CORPS - E.P.A. Program/ Land-Water Processes

	L-L-H	F-L	N	M	C	W
Land Use	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Population	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Commercial Activity / Municipal Finance	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −	√ ↑ + / √ ↓ −
Housing Supply	√ ↑ +	0	0	0	√ ↑ +	0
Education	√ ↑ +	0	0	0	√ ↑ +	0
Leisure Opportunities	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Cultural Opportunities	√ ↑ +	0	0	√ ↑ +	√ ↑ +	0
Transportation	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Municipal Services	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Security	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −
Community Image	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Community Cohesiveness	√ ↓ −	√ ↑ +	√ ↑ +	√ ↑ +	√ ↓ −	√ ↑ +
Citizen Involvement	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +	√ ↑ +
Institutional Relationships	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −	√ ↓ −

ENVIRONMENTAL PROTECTION AGENCY
Division of Water Hygiene
Northeastern Water Hygiene Laboratory
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July 29, 1971

Mr. Frank McGowan
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Corps of Engineers
Building 112 North
414 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. McGowan:

Many thanks for your letter of July 16, 1971. My preliminary comments on the effectiveness of various processes in elimination of viral pollutants are given below.

The assessments that follow represent opinions which have been derived by weaving the fragmental known facts with rationalization and speculation. Thus, they cannot be considered as conclusions of any sort. At the outset, some of the basic factors involved for the whole exercise should be discussed. First, the basic properties of the human enteric viruses are:

(a) A virus is formed by a definite number of subunits (capsmere) of nucleoprotein not coated with any substances.

(b) The shape of these viruses is generally spherical.

(c) The diameters of the spheres range from 10 mμ (Millimicron) to 100 mμ.

(d) They are resistant to lipid solvents, e.g. ether, and low pH of 3.0.

(e) In natural environment they may appear as clumps of varying numbers of viral spheres, embedded in cellular debris or coated by organic or inorganic substances present in their environment.

(f) Most likely, they would not multiply in the aquatic environment such as waste water.

Secondly, the fundamental processes of sewage treatment which could possibly render the virus harmless (inactivated) to human hosts include:

(a) <u>Aging</u>: Virus die during aging under any kind of circumstances, however, the time required for such event may vary considerably.

(b) Unfavorable conditions for viral survival: Most co-ditions deviating from the 'norma' for virus environ would speed up their die off. These processes are labelled as effective in inactivation of virus. These include heat, oxidation, ultraviolet light irradiation, etc.

(c) Adsorbents: Many earthen materials have the capability of adsorbing virus. Some are more efficacious than others. A varying degree of firmness is exhibited by the virus-adsorbent bindings. In general, the bindings are reversible and the virus is not being killed. These substances may be examplified by bentonite, charcoal, polyelectrolytes, various clay particles, etc.

(d) Filters: Virus does not go through the filter membranes with a porosity smaller than 10 mμ in diameter.

(e) Coagulation: Virus aggregates when mixed with coagulants such as $Al(OH)_3$. As the aggregates reach sufficient size, they would settle.

(f) Disinfectants: These chamicals possess specific effect in killing virus in a short order of contact. The examples for these compounds are: free chlorine, hypochlorite, ozone, etc.

(g) Chemical reactions: During the processes of sewage treatment, numerous chemical reactions may go on. Some of these reactions may have an impact on virus, however, little is known today except those listed above. For instance, the temperature rise, energy generation, chemical by-products resulted from these reactions may also facilitate killing of the virus.

With the above principles in mind, the following are only my opinion concerning the possible effects of each step of these systems on viral elimination and/or inactivation:

(1) Storage or lagoons

The mechanisms involved here on virus elimination are aging and adsorption onto the suspended particulates whatever present in the waste water.

As for storage alone, Chang (1) concluded after reviewing all available literature that this process is not dependent upon as an effective step for viral removal. Although aging would inactivate most virus in due time, there are many environmental conditions which may short circuit this effect, e.g., wind, convection current or rain may shorten the travel of virus through the storage pond to a matter of hours instead of weeks. The short circuits, however, would occur only in ponds of a continuous flow type. As for the inter-

mittent type of storage ponds, the natural die-out of virus should follow the aging pattern. In general, a 99.9% reduction takes place in a few weeks in warm weather and in a few months in cold seasons. In addition, the rates of die-out may be affected considerably also by other environmental factors.

With regard to the adsorption mechanism, many particulate matters in sewage may reduce viral concentrations in the water part, when the matters are settled or filtered out at a later stage.

(2) Primary settling

This process removes little of the viruses from sewage according to Berg (2). When poliovirus 1 was added to raw sewage, only 0-3% was removed by a three hour settling, although >50% solids had settled out. After 24 hours of settling, however, 40-70% of viral removal was observed.

Thus, this step cannot be relied upon for viral removal.

(3) Biologic treatments

(a) Activated sludge

Viruses are removed from sewage more efficiently by this process than by any other biologic means. 96-99% of coxsackievirus A9 added to the sludge was removed after a retention for 6-8½ hours. In other experiments, 88-94% of poliovirus 1 was removed after 6-7½ hours. In field studies in England, removals of 76-90% of polioviruses (1,2, and 3 types) were reported.

(b) Stabilization ponds

Viruses subject to not only the effects of adsorption and chemical insults occurring therein but also the various environmental factors such as sunlight, temperature, etc. Removal of viruses, however, is highly variable and responsive to many unknown factors. Shuval (3) found 0-96% removal after a twenty day retention. England reported that 19-87% of effluents from a pond fed with activated sludge contained viruses.

(c) Trickling filters

The process is of little value in removal of virus (4). Some reduction of virus was observed in the field by early studies. The amounts reduced varied from 10 to 50% in the influents.

(4) Physical chemical systems

(a) Coagulation

Coagulation of settled diluted wastewater effluent with $Al_2(SO_4)_3$ removed

96-97% of coliphage T_4 and 90-94% of phage MS2 (5). In undiluted sewage, considerable interference apparently occurred. This has been attributed to the presence of extraneous organic matter.

Coagulating activated sludge effluent with lime can remove 99-99.9% of poliovirus, if sufficient chemical is applied. At a concentration of 500 mg lime/l, pH of the effluents reached 11.1 which also contributed a considerable inactivation effect of the virus.

(b) Carbon adsorption

Filtration of secondary effluents through carbon did not efficiently remove tailed coliphage from trickling filter effluent (6). Adsorption to carbon, however, may be less efficient in the laboratory than in the field where microflora buildup and the availability of a variety of ions may bridge viruses to the particles. Hoff *et al* in our laboratory demonstrated that charcoal was capable of adsorbing poliovirus in fresh and seawater up to 90% when sufficient charcoal was added. This complex is rather firm, however, the virus is still infectious when even attached to the carbon particles.

(c) Filtration

Filtration through sand beds or soil has variable effect in removing viruses. Berg (7) concluded that clean sand does not adsorb virus, but poliovirus in lime-flocced effluent does not freely pass through a sand filter. Under the latter condition, 82-99.8% of virus was removed.

Percolation through dry river bed definitely removes a variety of viruses in secondary effluents as demonstrated in Santee (8). Unfortunately quantitative information is lacking.

Filtration through a semi-permeable membrane, typically a cellulose-acetate, as used in reverse osmosis, is theoretically effective in removing most viruses, provided the porosity of the membrane is very small, e.g., <10 mμ in diameter.

(d) Ion exchange resins

It is known that certain resins can adsorb virus. Kelly *et al* (9) used Dowex-1 resin 200-400 mesh, to concentrate viruses in sewage as a tool for concentration and testing of virus in this medium. Since virus could be eluted from it for later testing, they were apparently not killed and also the process is a reverse one.

(e) Polyelectrolytes

These substances can adsorb virus efficiently under certain conditions. For instance, PE60 can adsorb a variety of enterovirus in fresh water up to 95%, but not in sea water or water containing high concentrations of organic matters. Other polyelectrolytes, however, can adsorb viruses in sea waters.

(5) Specific systems

(a) Overland flow

In this system, a number of steps may reduce viral contents in sewage. These include aging, adsorption onto all sorts of clay particles, environmental insults, and others. Some laboratory studies have been done by Chang *et al* in URI and demonstrated that some clay particles are very effective in adsorbing poliovirus, but others are very poor adsorbers. Some reports on waterborne hepatitis outbreaks suggested that some type of soil permitted the virus to travel freely from the cesspool to the well underground. Research effort is urgently needed in order to determine what types of soil may be helpful in viral eliminations. By the same token, the effect of numerous environmental factors on viral inactivation also needs to be investigated.

Therefore, the approximate effect of this total system in viral elimination is hard to predict because too many variables are involved. But this system does not include any obvious step which can safeguard a high order of viral elimination.

(b) Spray irrigation and infiltration

Steps in this system for viral elimination are aging and sand filtration. As pointed out above, neither of these steps can be relied upon for an effective viral elimination. It is clear, however, that there would be no short circuit of aging possibly associated in storage. Then the total length of time would be an important factor for achieving the desired effect. Of course, other environmental factors should be taken into consideration.

In addition, the sandy soil may contain certain types of clay having variable efficiency in viral adsoprtion. Thus, the composition of the soil involved should be definitely identified and tested for the capability of virus adsorption before a more valid assessment can be offered.

In total, the whole system does not seem to have a very strong barrier for virus.

(c) Infiltration basin

This system appears to be similar to the above one except for no crops. Also it differs from the above in the rate of filtration and the intermittent practice. While the intermittent nature is more advantageous in viral elimination, the faster rate of filtration is a drawback in this regard.

Likewise, this system does not seem to afford a strong barrier for virus.

The above are only my considered opinions. If I have missed something or have not made it clear, please do not hesitate to call me or drop me a line.

Sincerely yours,

Oscar

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NOTES ON CONFERENCE OF CONSULTANTS

WASTEWATER MANAGEMENT PROGRAM

FOR THE MERRIMACK RIVER BASIN

UNIVERSITY OF MASSACHUSETTS

May 17 - 20, 1971

Bernard B. Berger, Director
Water Resources Research Center
University of Massachusetts

General

The meeting represented in effect a confrontation between two schools of thought concerning the preferred method of conditioning wastewaters to attain a degree of purity equivalent to that of acceptable drinking water: land disposal and advanced waste treatment. The first would utilize biological treatment in aerated ponds followed by spreading of effluent on flooding beds to permit recharge of ground water, or interception of percolate for return to the original water source. The advanced waste treatment system would utilize a sequence of physical-chemical processes for separation of impurities from the water with or without preliminary treatment by biological methods. Neither of these methods is, in my opinion, sufficiently mature at this time to permit use at full field scale with a high degree of confidence in plant performance. Important questions remain to be answered for each of the proposed methods. It appears timely that these questions be clearly stated and that appropriate steps be taken to obtain the necessary information preliminary to preparation of plans for full field scale evaluation. Beyond this, it is essential that concepts based on laboratory and pilot plant studies be tested on a scale representing regional systems for waste water treatment.

<u>Land Disposal</u>

I had the following reactions to the presentation on land disposal of wastewater: 1) The use of aerated ponds as a biological treatment device warrants intensive reexamination. An extensive literature exists on the use of waste stabilization ponds which of course depend on natural reaeration. Generally speaking, the results of such treatment are satisfactory even in the North Central part of the United States where weather conditions presumably are most rigorous. The major deterrent to the use of waste stabilization pond is the large amount of land required. Therefore, only where suitable land is available at low cost would this system of waste treatment be attractive.

The use of the aerated pond reduces the required land area substantially while apparently providing all of the benefits of the waste stabilization pond. These benefits include an extended aeration period with consequent aerobic digestion of sludge. I believe that an examination of the literature on such ponds and on extended aeration systems generally would be most desirable. In this study, the utility of the pond as a storage device for the reception of the increased flows associated with storm runoff should be evaluated. It seems reasonable to assume that a pond designed to provide a three day detention of normal flows could be useful in storing and equalizing flood flows. Moreover, it also seems reasonable that these ponds would be less subject than conventional biological treatment devices to the toxic effects of slugs of industrial wastes.

I frankly feel that the aerated pond can be very useful in a regional wastewater treatment system, whichever system is subsequently employed: land disposal or advanced waste treatment.

2) I cannot feel comfortable with the idea of employing flooding beds in New England. While much of our surface strata is composed of glacial till and is fairly permeable, such formations are interspersed with layers of clay which may offer barriers to percolation. I would question, therefore, the assumption that flooding beds in this part of the country may be depended on to accept 150 feet of water per year for an indefinite future even when operated on an intermittent wet-dry schedule. I have no doubt that there are areas in New England favorable to such use, but I believe one should not generalize on the basis of the relatively limited data available.

It is interesting to note that pilot field studies on recharge of biologically treated effluents into dune sand conducted in Israel showed that infiltration rate was reduced from about 32 in/day to 20 in/day after 2 1/2 years of operation. The experimental beds were operated on a wet-dry cycle such that 5 days of flooding required 10 days of rest. Thus the total flooding area required was equal to 3 times the area flooded at any time. It was determined that resistance to percolation resulting from physical and chemical changes in clay lenses below the surface sand was a major factor in reducing the infiltration rate.

It is possible that valuable information on infiltration rates may be obtained from study of waste stabilization ponds in New England. A number of such ponds are in use and it may very well be that such information may be extracted from their operating experience.

I must admit I also feel very uncomfortable with the assumption that problems of freezing in the flooding beds may be readily handled. After three days of retention in the aeration ponds, I would assume that the

temperature of the pond effluent would be very close to that of the ambient air temperature and in the winter time, therefore, very close to freezing. The application of heat to this effluent in the flooding beds would seem to me to be a rather expensive operation and possibly risky. If the heating system fails and freezing occurred, and this certainly could happen, I can see all kinds of messy problems resulting. I have little faith in the use of styrofoam covers in the flooding beds. It is one thing to say that such insulating material is useful, it is quite another to go ahead and depend on them. I would want to see some careful studies made before I would accept the use of this material for the purpose indicated.

3) I cannot accept the statement that the soil can be depended on to do an adequate job of nitrifying ammonia and organic nitrogen compounds and denitrifying the nitrates to evolve nitrogen gas. Perhaps this can be demonstrated in the laboratory under carefully controlled conditions, but I would hesitate to extend conclusions based on such data to the field. I would be more inclined to believe a given soil has a finite capacity to accept and modify nitrogenous compounds and that this capacity would be substantially reduced in cold weather. The suggestion that oxidizing conditions may be maintained under all conditions in the upper three feet of the soil by aeration tubes seems highly speculative. (Reports from Israel indicate that nitrates in recharged groundwaters reach a concentration of approximately 120 ppm, about three times that permitted by the USPHS Drinking Water Standards.)

4) The land disposal method should have no appreciable effect on the removal of dissolved inorganic materials other than nitrates (possibly) and phosphates. While many such materials may be removed through ion exchange

processes in the soil, the degree and dependability of such removal are most uncertain and would justify an assumption that this removal would be insignificant. In a system of recycling of waste waters, therefore, these materials, which presumably would include the heavy metals, would increase in concentration with each cycle.

5) It was indicated that the recycling scheme would involve the installation of a subsoil water capture system. While there is no reason to doubt that this can be done, it should certainly add appreciably to the cost of the total system. The efficiency of capture would be something less than 100% under most field operating conditions.

6) It was indicated that for the Lawrence, Lowell, Haverill system some 4,000 acres of land would be required for flooding purposes. One might examine the ecologic consequences of coopting such an appreciable land surface for purposes of flooding. It appears reasonable to assume that significant ecologic changes could be induced. Conceivably, the results might be beneficial. Until this is established, however, it would be desirable to assume that such land use would produce undesirable effects.

7) One further thought occurs to me in connection with the use of land for waste disposal: the impact of future regional land development on such land use. Massachusetts currently is undergoing an examination of policy in respect to land use regulation in connection with future regional development. For example, one hears more and more about the possibility that flood plains will be used as an alternative to the use of dams for flood control purposes. Recharge beds located in the flood plain would be useless if the area is inundated by Merrimack River flood

waters. Beyond this, the possibility exists that an investment in land disposal of wastewaters might be lost if this use is not in accord with regional longterm plans for development of the land in question.

Advanced Waste Treatment

The use of advanced waste treatment processes can, in my opinion, meet the challenges of the future in respect to the renovation of wastewater. However, a number of uncertainties must be clarified before full confidence may be placed in a sequence of such processes to do the job dependably. These are discussed below:

1) The disposal of sludge presents a particularly difficult problem because of the voluminous character of sludge produced by chemical treatment processes. While such sludges may be thickened, vacuum-filtered and incinerated, the costs associated with sludge handling and disposal could be high. These costs should be examined very carefully because they might represent an appreciable part of the total cost of waste treatment.

2) The disposal of concentrated brines resulting from the use of ion exchange and membrane processes may be troublesome. While presumably such brines can be conveniently disposed of in coastal waters, the cost of conveying brine from inland points of production to the coastal area might be significant. I can see no other way of disposal of brines in New England than conveyance to the sea. The use of deep wells or evaporation ponds appears to be out of the question for this purpose.

3) I believe the problems of sliming will prove to be a continuing difficulty. The sequence of processes with activated carbon preceeding the filtration process, as is proposed, guarantees that slime will form

on the carbon. It was indicated that these slimes will not interfere seriously with the adsorption capacity of the carbon; in any case, a continuing sloughing off of the slime will reexpose adsorption sites on the carbon for the removal of organic compounds. However, I am inclined to believe that substrates and slime forming organisms will reach the ion exchange beds and reverse osmosis membranes and produce fouling difficulties. Just how important this will be is uncertain. We need additional experience to evaluate this problem and to determine what additional pretreatment processes are required to protect ion exchange materials and membranes. Further, it is not clear to me that problems of clogging of ion exchange materials and membranes may be eliminated with confidence.

4) It is not certain that we are yet able to produce reverse osmosis membranes that have a satisfactory life under realistic conditions of use.

5) While the application of advanced waste treatment processes seems to have an attractive future, it is important that they be incorporated in a full field scale experimental plant to determine how they will perform under actual operating conditions. There may be a significant difference between performance in a pilot plant under careful and skilled operation and performance under realistic field conditions. I urge, therefore, that the Corps of Engineers together with EPA provide, as soon as feasible, a facility which presents a range of operating challenges representative of the conditions in most American regions.

Recommendations

In my opinion, a combination of biological treatment and advanced waste treatment would provide the best of all methods for renovating wastewaters. In this case, I feel very much attracted to the idea of utilizing extended aeration systems as represented by aeration ponds with three day retention of normal flow. The advantage of such system in providing storage for storm waters and in protecting against slugs of industrial wastes is a strong argument in favor of using the aeration ponds in the sequence of advanced waste treatment processes. Again I would urge that an examination of the literature be made without delay to determine the actual utility of such ponds. If in the future it appears that the advanced waste treatment process need not depend on pretreatment by aeration pond, the latter could easily be abandoned, or preferably, be maintained for stand-by purposes and for storage of storm flows.

Because of the interest in regional systems of wastewater management and in the utilization of unconventional methodology for conditioning the wastes, I would urge that a careful evaluation be made of the work and operating experience of other countries sharing this interest. Two locations in particular might be examined: the DAN project for the reclamation of wastewater from the City of Tel Aviv, Israel and the Windhoek reclamation project in South Africa. I am attaching the following reprints of articles dealing with each of these programs:

Waste Treatment for Ground Water Recharge by Aaron Amramy presented at The Second International Conference on Water Pollution Research in 1964

<u>The Full Scale Reclamation of Purified Sewage Effluent for the Augmentation of the Domestic Supplies of the City of Windhoek</u> by L. I. J. VanBuuren, M. R. Henzen and G. J. Stander presented at the Fifth International Conference on Water Pollution Research.

The above articles do not provide a complete understanding of problems and operating experiences at the locations described but they do present an idea of how other countries requiring the reclamation of wastewater are going about doing the job. It would be desirable in my opinion that a representative of the Corps of Engineers visited the above places to obtain first hand knowledge on these projects. For example, I am certain that more recent information is available on the DAN Reclamation Project than is contained in the Amramy article cited. I would include the following questions among those for which answers should be sought:

1) What actual operating problems have been experienced? How are they being handled?
2) What problems encountered are not presently controllable in satisfactory manner?
3) What new knowledge has been gained as a result of field scale operation? How has this new knowledge affected plant operation and performance?
4) Were the system to be redesigned, what changes would be made?
5) Which tests are considered to be essential to effective system operation (nature of analyses, and sampling procedures and frequency) and how are test data utilized?
6) What laboratory support is essential to plant operation?

7) What level of skill is required in operators?

8) What cost figures are associated with the project?